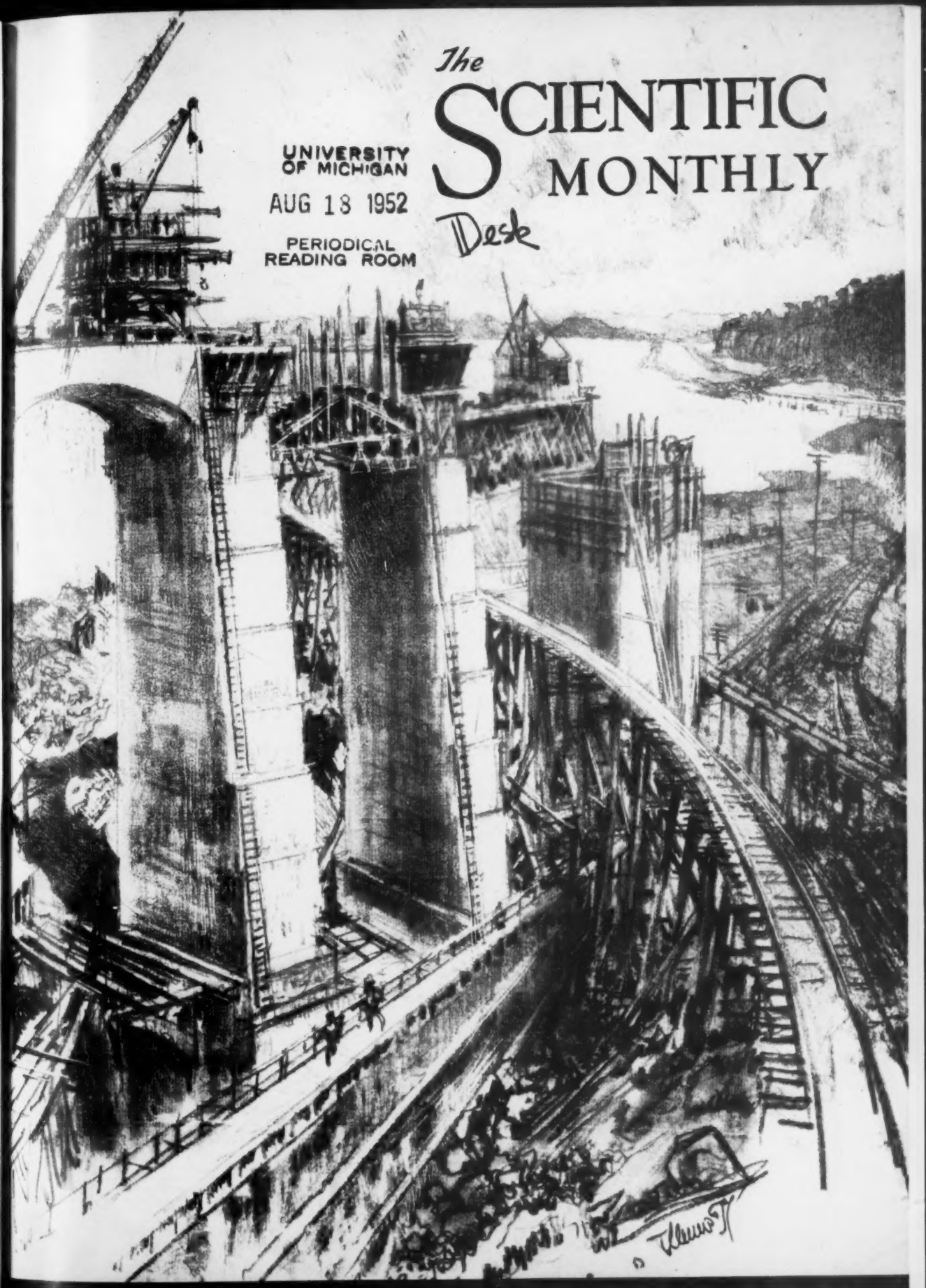



LXXV NO 2 AUGUST 1952

# What GENERAL ELECTRIC People Are Saying

T. TROCKI
*Knolls Atomic Power Laboratory*

HANDLING LIQUID METALS: Liquid metals have singular advantages as heat-transfer agents for certain high-temperature applications in our modern industrial economy.

The basis for the successful handling of chemically active or personally hazardous materials is to contain them in an inert atmosphere and prevent leakage.

Obviously, the success of any such system depends on the use of a structural material which will not be corroded by the contained liquid metal. It is, therefore, fortunate that many of the high-temperature structural materials are compatible with liquid metals as long as proper precautions are taken to purify the liquid metals initially and keep them clean.

Oxygen appears to be the principal contaminant affecting corrosion, and it must be kept to a minimum. In boiler water the oxygen content is controlled by removing the oxygen at low temperature, when it is practically insoluble in water, and depending upon chemical "getters" at high temperature, when any remaining oxygen is released—and is most corrosive.

Oxygen solubility in liquid metals is also temperature dependent, and this is used as the basis for oxygen removal. Getters have also been investigated for liquid metals, but their effectiveness has not been established.

It can be seen from the foregoing that leak-tightness is the most important single requirement for a liquid-metal system. The difficulties resulting from leakage of liquid metal in such a system vary with the liquid metal concerned. Some of the metals—like lithium, sodium, and potassium—burn in air; others—like lead and mercury—are toxic. And any material at high temperature will burn flesh.

Broadly speaking, the development leading to the successful handling of liquid metals has been devoted, first, to gaining an understanding of the limits and control of liquid-metal contamination, with the object of controlling corrosion; and, second, to developing leakproof heat exchangers, pumps, valves, and system auxiliaries.

*G-E Review*
*May 1952*

K. H. KINGDON
*Knolls Atomic Power Laboratory*

MILITARY NUCLEAR POWER: Military considerations frequently demand that a vehicle shall be able to maintain high speed for a long time, and both these requirements are made available by using a concentrated fuel. Nuclear fuel, with its million-fold great concentration of energy over conventional fuels, is a natural for such military applications.

The most important features of a mobile military nuclear power plant are reliability, compactness, and light weight. A great deal of attention is being given to these features in the plants under development. The requirement for a biological shield to contain the dangerous nuclear radiations within the power plant of an inhabited vehicle makes the requirement of light weight a particularly difficult one to satisfy. This is especially so because there is nothing very smart that one can do about absorbing gamma rays, which only can be absorbed by relatively large thicknesses of heavy materials. These thicknesses are of the order of a few feet for materials like water and concrete, and of the order of a few inches for a very heavy material like lead. Fortunately, although the weight of shielding needed for an inhabited vehicle is awkward, it is not prohibitive.

There is also the question of the damage which may be done to the materials in the power plant by the intense nuclear radiations, damage which may be serious enough to cause failure of some component. Extensive investigations are being made of this radiation damage. It appears that neither the unfamiliar materials with which one has to work, nor the effects of radiation on the materials of the plant, is likely to prove to be a prohibitive limitation on the development of mobile military nuclear power.

*Harvard Engineering Society*
*Boston, Massachusetts*
*April 17, 1952*

*You can put your confidence in*

GENERAL ELECTRIC

# THE SCIENTIFIC MONTHLY

VOL. LXXV AUGUST 1952 NO. 2

## Contents

The Gatun Locks in the Panama Canal–1912 . . . . . Cover
*(Courtesy Metropolitan Museum of Art)*
Methodology Conference, Central Statistical Administration, USSR . . *Stuart A. Rice* 71
Form and Function: A Problem in Biophysics . . . . . *Max A. Lauffer* 79
Multiple-Purpose River Planning and Development . . . *Morris Llewellyn Cooke* 84
The Cause of the Great Ice Ages . . . . . *Karl A. Pauly* 89
A Century of Engineering Progress: 1852–1952 . . . . . *James Kip Finch* 99
Aimlessness in Education . . . . . *Arthur E. Bestor, Jr.* 109
Disagreement: The Situation of Reason . . . . . *Martin S. Dworkin* 117
The Riddle of the Skies (*Verse*) . . . . . *Florence Holcomb Martin* 119
Science on the March:
The Role of Geophysics in Expanding Mineral Production . . . *Sherwin F. Kelly* 120
Book Reviews by *H. H. Bartlett, A. Cornelius Benjamin, Richard Berlin, Arthur Bevan, Kenneth E. Boulding, W. S. Connor, Carter Davidson, Rudolf Flesch, C. H. Hoffmann, J. S. Hunter, G. A. Johnsgard, Carl D. La Rue, Lucile Q. Mann, W. M. Mann, Claudius F. Mayer, Dietrich C. Smith, I. E. Stewart,* and *D. ter Haar* . . 123
Letters from *Jeanne Burbank, Joseph Lewis, Max S. Marshall, Velma West Sykes,* and *Mary M. Waterman* . . . . . 135
Association Affairs . . . . . 137

***Annual Meeting, AAAS, St. Louis, Missouri, December 26–31, 1952***

GLADYS M. KEENER, Executive Editor

EDITORIAL BOARD OF THE AAAS

*(Terms expire June 30, 1953)*

HOWARD A. MEYERHOFF, *Chairman*
WILLIAM R. AMBERSON
WALLACE R. BRODE
BENTLEY GLASS
K. LARK-HOROVITZ
WALTER J. NICKERSON

F. A. MOULTON, Advertising Representative

Established 1872 as *The Popular Science Monthly;* since 1915 an official publication of the American Association for the Advancement of Science.

Publication office, Business Press, Inc., 10 McGovern Ave., Lancaster, Pa. Orders for subscriptions and requests for change of address should be directed to the Circulation Department, A.A.A.S., 1515 Massachusetts Ave., N.W., Washington 5, D. C. Subscriptions: $7.50 per year; single copies 75 cents. Four weeks are required to effect change of address.

Address all correspondence concerning editorial matters and advertising to THE SCIENTIFIC MONTHLY, 1515 Massachusetts Ave., N.W., Washington 5, D. C. The editors are not responsible for loss or injury of manuscripts and photographs while in their possession or in transit; all manuscripts should be accompanied by return postage. The American Association for the Advancement of Science assumes no responsibility for the statements and opinions expressed by contributors.

Copyright, 1952, by the American Association for the Advancement of Science. Entered as second-class matter at the Post Office at Lancaster, Pa., December 30, 1947, under the Act of March 3, 1879. Acceptance for mailing at the special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph (d-2) Section 34.40 P.L. & R. of 1948. Indexed in the *Reader's Guide to Periodical Literature.* The A.A.A.S. also publishes SCIENCE. Subscription and advertising rates on request.

Cable address: ADVANCESCI.

# Science and Technology

*(From the Month's News Releases)*

### Hot Weather Tips for Hot Weather Hazards

Antifungal cement may soon make athlete's foot around swimming pools, locker rooms, and showers a thing of the past. Research by Radcliffe F. Robinson, of Battelle Memorial Institute, has shown that concrete containing 10 per cent copper acetoarsenite can be effective for at least two or three years in preventing the growth of *Epidermophyton interdigitale* (mold to you), one of the known causes of athlete's foot. Finishing layers of light-green concrete containing the copper additive would eliminate the necessity of painting. Other uses predicted for the antifungal cement would be in industrial kitchens, slaughterhouses, and concrete tunnels for plant cooling systems.

Phenergan hydrochloride, a phenothiazine derivative, and a potent antihistamine, is reported in the *Annals of Allergy* to have given relief to patients suffering from pollen hay fever. Symptoms were said to have been relieved within half an hour in practically all patients who responded; total percentage (of 102 patients) who benefited was 92.16. The tests were made under the supervision of N. E. Silbert, of Lynn, Mass.

New remedies for poison ivy include zirconium used in a vanishing cream-type of ointment, now manufactured by two different pharmaceutical houses. Also available this year is a liquid extract of the plant leaves, injected under the skin and used either as a treatment or as effective, long-lasting immunization that works for eight out of ten persons.

### Paper Work Get You Down?

Copyfix takes less than a minute to produce photo-exact finished positives of any office record, regardless of type or color, from originals up to 14 inches wide, in any length. No special installation is required—the machine operates from any electrical outlet and no darkroom is needed.

A bantam microfilmer allows the filing of 29,000 bank checks (1/40th their original size), or 290 per foot, on 100-foot rolls of 16mm film. Accessory lenses make possible three other reductions. The instrument will accept documents up to 11 inches wide and of unlimited length, and it may be purchased outright or rented.

### Simplified Charts

Fisher Scientific Instrument Co. has added a small, inexpensive Periodic Chart to its lecture and office sizes. Printed on white cardboard and punched to fit a three-ring binder, it includes atom numbers printed in red, symbols, atomic weights, and the orbital electron distributions for the noble gas elements. A four-place logarithm table and an electromotive force table of the elements with the respective ions are printed on the reverse side.

### Versatile Tools

A pistol-shaped automatic acetylene-air gas torch lights at the squeeze of the trigger and shuts off upon release, saving time, work, fuel, and matches, and reducing fire hazard. The trigger can also be locked open for continuous flame. May be used for soldering, sweating copper fittings, light brazing, removing paint, loosening nuts and bolts, heating tile mastic, straightening fenders, and heating putty.

A combination tool may be used as a compass (makes circles up to 15″ in diameter), as an 8½″ scale, as a straight edge, as a protractor, as a T-square, and as a marking gauge.

Snapback timing, straight timing, and time-out operation are all possible with a new stop clock for laboratory and industrial applications. Spring-wound for portability, it has a 4″ dial for reading at a distance, and costs less than an ordinary stop watch.

A clamp that combines the best features and the strength of a standard drop-forged "C" clamp and a toolmaker's parallel clamp eliminates distortion and twisting action, absorbs vibration, and gives great freedom of motion and operation. Light weight and ease of operation make it suitable for use by women employees. It has three different gripping faces to accommodate all types of holding jobs, such as rough welding, general assembly, fast production, or delicate tool and die work.

A thermometer that works like a trombone is made in two different stem lengths for flasks ranging from 250 to 22,000 ml. Both sizes are available in three ranges: 0°–150° C, 0°–250° C, and 0°–360° C. The manufacturer claims that in addition to taking the liquid temperature, one may also obtain the vapor temperature by lifting up the thermometer, without dismantling the equipment.

### Saws

A saw filing jig that may be used as a jointer is equipped with depth adjuster and bevel guide. The jig is held on the saw by set screws, and depth-control rollers prevent overfiling.

For plywood and fine cross-cutting a new round disposable blade eliminates saw sharpening problems. According to the manufacturer, the blades stay sharp four to six times longer than usual and save up to 60% in sawing costs. When the blade finally becomes dull, throw it away like an old razor blade. Comes in all standard bores and all bores to fit electric handsaw machines.

---

Address a post card to Science and Technology, 1515 Massachusetts Ave., N.W., Washington 5, D. C., for further information about any item on pages iv and v.

### Sharp Seeing

A wide-angle photographic lens, the Metrogon, enables a single aerial photograph to show three times as much area as was previously possible from the same altitude. According to tests by the Bausch & Lomb Scientific Bureau, a photo from an altitude of a mile can show separate railroad ties anywhere within a two-mile radius beneath the plane. The distortion usually prominent in all wide-angle photos has been almost completely eliminated, and RB-36 bombers of the Strategic Reconnaissance Command, some of which are currently flying round-the-clock training missions, have been able to obtain aerial photographs and reconnaissance data under any weather conditions, day or night.

A bombardier and flight engineer, who is also a medical researcher in the Air Force School of Aviation Medicine, is working on a combination of green plastic canopy and red goggles to replace the blue-amber combination now in use in blind flying practice.

The Naval Ordnance Laboratory Photographic Division has developed a hand-held tracking camera that is especially useful for shooting from moving bases such as a rocking boat. The new camera makes use of a padded shoulder mount and may be used with gloves on, if necessary. It has been used in such studies as tracking an airplane traveling at high speeds, catching the actual time of missile launching, following the entire range of drop of the missile, and to show live parachute jumps.

Electronic distance-measuring equipment consists of one master unit with indicating or recording equipment, or both, and one relay station with whip antenna. The system operates by measuring the distance between the two units and is available with a relay unit for portable land applications or incorporated into especially designed floating buoys for use in trial tests of ships, studies of tides, and in hydrographic and hydrodynamic testing and research.



Section of a photograph made with the Armagh-Dunsink-Harvard (ADH) telescope, the only Schmidt-type in South Africa. Part shown covers only 10 per cent of the total area of perfect optical definition of the original photograph, and is a portion of the beautiful Eta Carina Nebula, one of the finest gaseous nebulae in the Southern Hemisphere. White dots are stars, some of them blue-white giants a thousand to ten thousand times as bright as our sun. Eta Carina is 500 light years from the sun and measures at least 200 light years across. It marks the center of an extended region of bright nebulosity and indicates, in all probability, the direction toward a "knot" in one of the spiral arms of our galaxy.

**GBI CATALOG No. 677**

Lists more than 300 items for Research — Biological, Microbiological, Bacteriological, Biochemical, Nutritional. Write

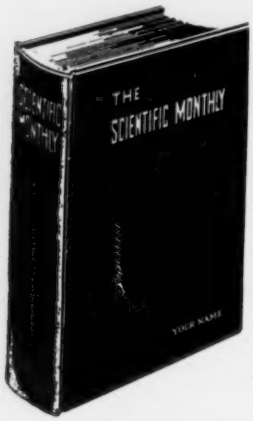
**GENERAL BIOCHEMICALS, INC.**

73 LABORATORY PARK • CHAGRIN FALLS, OHIO

*the* **technicon COMPANY**

offers precision equipment for the chemical and pathological laboratory.

THE TECHNICON COMPANY
215 East 149th Street New York 51, N.Y.




**Preserve your SM copies for quick, easy reference with attractive**

**<< BINDERS**

**$2.75** each-PP in USA. (Name-70¢; year 40¢ extra) Personal check or Money Order, please!

**The SCIENTIFIC MONTHLY** 1515 Mass. Ave., N.W. Washington 5, D. C.

**NEW!** **ALLEN REFERENCE SETS**

For Microscopical Studies in Mineralogy and Petrology

Write for Leaflet RA-SM

R. P. CARGILLE, 117 Liberty St., N. Y. 6, N. Y.

*For Modern Tools of Science*

E. MACHLETT & SON

Laboratory Apparatus • Supplies • Chemicals

220 East 23 Street • New York 10, N. Y.


# PITUITARY-ADRENAL FUNCTION

***published February 1951***
***2nd printing June 1951***

6 × 9 inches, illustrated, clothbound, 224 pages—$4.00
Price to AAAS members for prepaid orders—$3.50

**PITUITARY-ADRENAL FUNCTION** continues the AAAS tradition of presenting in book form the collected papers presented at symposium programs of wide interest. This volume includes 22 papers delivered at a two-day Symposium on the Adrenal Cortex at the AAAS meeting in New York City, December 1949.

**PITUITARY-ADRENAL FUNCTION** assembles important contributions of a score of laboratories in the United States and Canada from which many of the recent major advances in pituitary-adrenal physiology and therapeutics have come, and includes studies on the regulation of adrenal cortical activity, the role of the cortical hormones in protein, carbohydrate, and mineral metabolism, and effects of the cortical steroids and the ACTH in various disease states. A summary chapter on "Adrenolescence" by Dr. George Perera forecasts some of the possible future trends in this active field of endocrine research.

**ORDER NOW**

TO: AAAS PUBLICATIONS
1515 Mass. Ave., N.W., Washington 5, D. C.

Enclosed is $..... Please accept my order

for ..... copies of

PITUITARY-ADRENAL FUNCTION

Name .....

Address .....

City ..... Zone.... State .....

# New Books Received

*Bone Tumors.* Louis Lichtenstein. 315 pp. Illus. $10.50. Mosby, St. Louis. 1952.

*Principles of Refraction.* Sylvester Judd Beach. 158 pp. $4.00. Mosby, St. Louis. 1952.

*Elements of Wave Mechanics.* N. F. Mott. 156 pp. $3.75. Cambridge University Press, London and New York. 1952.

*Reports on Progress in Physics,* Vol. XV. A. C. Stickland, Ed. 338 pp. Illus. £2 10*s*. Physical Society, London. 1952.

*The Alkaloids, Chemistry and Physiology,* Vol. II. R. H. F. Manske and H. L. Holmes, Eds. viii + 587 pp. (No price given.) Academic Press, New York. 1952.

*Méthodes et Réactions de l'Analyse Organique, Méthodes de l'Analyse Generale,* Vol. I. Léon Velluz. 276 pp. 1,800 fr. Masson & Cie., Paris. 1952.

*Atomic Power, An Economic and Social Analysis.* A Study in Industrial Location and Regional Economic Development. Walter Isard and Vincent Whitney. xi + 235 pp. $4.75. Blakiston, Philadelphia. 1952.

*Elementary Analysis.* Kenneth O. May. xviii + 635 pp. $5.00. Wiley, New York; Chapman & Hall, London. 1952.

*Miscellaneous Physical and Chemical Techniques of the Los Alamos Project.* National Nuclear Energy Series, Manhattan Project Technical Section, Division V, Vol. 3. Alvin C. Graves and Darol K. Froman, Eds. xiii + 323 pp. Illus. $4.00. McGraw-Hill, New York. 1952.

*Probit Analysis.* (2nd ed.) A Statistical Treatment of the Sigmoid Response Curve. D. J. Finney. xiv + 318 pp. $7.00. Cambridge University Press, New York. 1952.

*International Health Organizations and their Work.* Neville M. Goodman. xi + 327 pp. Illus. $6.50. Blakiston, Philadelphia. 1952.

*Systematic College Chemistry.* Lytle Raymond Parks and Warren H. Steinbach. viii + 692 pp. Illus. $5.50. Blakiston, Philadelphia. 1952.

*Introductory General Chemistry.* John E. Cavelti. xi + 423 pp. Illus. $4.50. Blakiston, Philadelphia. 1952.

*Soil Physical Conditions and Plant Growth. Agronomy, A Series of Monographs,* Vol. II. Byron T. Shaw, Ed. xv + 491 pp. Illus. $8.80. Academic Press, New York. 1952.

*The Counter-Revolution of Science.* Studies on the Abuse of Reason. F. A. Hayek. 255 pp. $4.00. Free Press, Glencoe, Ill. 1952.

*Medical Biographies.* The Ailments of Thirty-Three Famous Persons. Philip Marshall Dale. xii + 259 pp. $4.00. University of Oklahoma Press, Norman. 1952.

*Should Fatherhood Begin at Forty?* E. Orson Brower. xvi + 240 pp. $3.25. Author, Philadelphia. 1952.

*The Mitotic Cycle.* The Cytoplasm and Nucleus During Interphase and Mitosis. Arthur Hughes. viii + 232 pp. Illus. $6.00. Academic Press, New York; Butterworths Scientific Publications, London. 1952.

*Turkish Crossroads.* Bernard Newman. 258 pp. Illus. $4.75. Philosophical Library, New York. 1952.

*Management Controls in Industrial Research Organizations.* Robert N. Anthony, assisted by John S. Day. xviii + 538 pp. Illus. $6.75. Harvard Business School, Division of Research, Boston. 1952.

*Foundations of Analysis.* The Arithmetic of Whole, Rational, Irrational and Complex Numbers. Edmund Landau. xiv + 134 pp. $3.25. Chelsea Pub., New York. 1951.

*A Guide to the History of Science.* George Sarton. xviii + 316 pp. $7.50. Chronica Botanica, Waltham, Mass.; Stechert-Hafner, New York. 1952.

*Economic Anthropology.* A Study in Comparative Economics. Melville J. Herskovits. xiv + 552 pp. + index. $7.50 trade, $5.75 text. Knopf, New York. 1952.

*Essays on Liberty.* 37 essays by various authors. 310 pp. $1.50 paper; $2.50 cloth. Foundation for Economic Education, Inc., Irvington-on-Hudson, N. Y. 1952.

*The Origin of Life and the Evolution of Living Things.* An Environmental Theory. Olan R. Hyndman. xxii + 648 pp. $8.75. Philosophical Library, New York. 1952.

*Bacteria.* Stanley Thomas and Thomas H. Grainger. viii + 624 pp. Illus. $5.50. Blakiston, Philadelphia. 1952.

*The Horse-Flies (Diptera: Tabanidae) of the Ethiopian Region.* Vol. I, *Haematopota and Hippocentrum.* H. Oldroyd. x + 226 pp. Illus. £2. British Museum (Natural History), London. 1952.

*Hyperconjugation.* John William Baker. viii + 160 pp. $3.50. Oxford University Press, New York. 1952.

*The Auger Effect and other Radiationless Transitions.* Cambridge Monographs on Physics. E. H. S. Burhop. xiv + 190 pp. + 5 plates. Illus. $5.50. Cambridge University Press, New York. 1952.

*A Course in College Chemistry.* V. R. Damerell. x + 588 pp. Illus. $5.50. Macmillan, New York. 1952.

*Theory of Matrices.* Sam Perlis. xiv + 238 pp. $5.50. Addison-Wesley Press, Cambridge, Mass. 1952.

*Advanced Calculus.* Wilfred Kaplan. xiv + 680 pp. Illus. $8.50. Addison-Wesley Press, Cambridge, Mass. 1952.

*The Atmosphere.* Peter Hood. 64 pp. Illus. $2.50. Oxford University Press, New York; Geoffrey Cumberlege, London. 1952.

*The Theory of Relativity.* The International Series of Monographs on Physics. C. Møller. xii + 388 pp. $7.00. Oxford University Press, New York. 1952.

*Reports of the Biochemical Research Foundation of the Franklin Institute,* Vol. XI, 1950–1951. With an index to BRF Publications Nos. 1 to 260 and BRF Notes November 1938 to December 1951. Bound in Reports from the Biochemical Research Foundation. Vols. I to XI, 1930–1951. Ellice McDonald, Director. (No price given.) Biochemical Research Foundation of the Franklin Institute, Newark, Del.

*Statistical Theory with Engineering Applications.* A. Hald. xii + 784 pp. $9.00. Wiley, New York; Chapman & Hall, London. 1952.

*From Atomos to Atom.* The History of the Concept *Atom.* Andrew G. Van Melsen. Trans. by Henry J. Koren. xii + 240 pp. $4.25. Duquesne University Press, Pittsburgh. 1952.

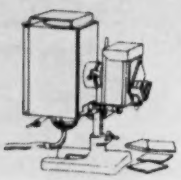
*The Sources and Nature of the Statistics of the United Kingdom.* Vol. I. Maurice G. Kendall, Ed. viii + 352 pp. 21/–. Oliver and Boyd (published for the Royal Statistical Society), London. 1952.

*Methods of Algebraic Geometry,* Vol. II. W. V. D. Hodge and D. Pedoe. ix + 394 pp. $7.50. Cambridge University Press, New York. 1952.

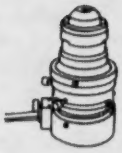
*Geometry and the Imagination.* D. Hilbert and S. Cohn-Vossen. ix + 358 pp. Illus. $5.00. Chelsea Pub., New York. 1952.

*Principles of Mathematical Logic.* D. Hilbert and W. Ackerman. xii + 172 pp. $3.50. Chelsea Pub., New York. 1950.

*James Cook.* Edwin Henning. viii + 141 pp. Illus. 9.50 DM. Wissenschaftliche Verlag, Stuttgart. 1952.



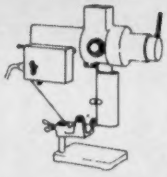
Research Illuminator



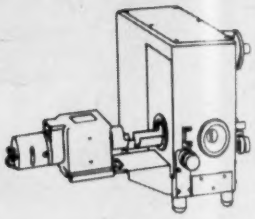
Panfocal Illuminator



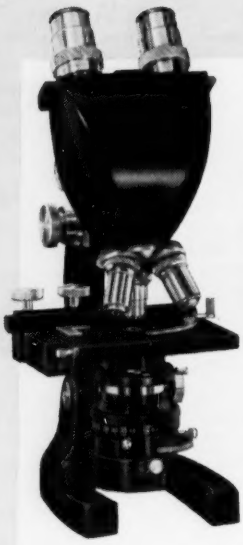
Micro-Lite



Arc Illuminator

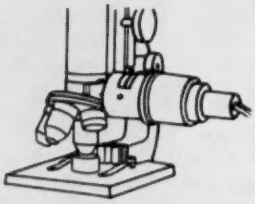


Grating Monochromator



# ENGINEERED LIGHTING

## for every microscopy need . . .



Tri-Vert Illuminator



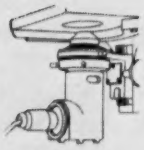
Nicholas Illuminator



Fluorescent Illuminator



Reflector Illuminator



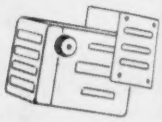
Dark Field Illuminator



Spherical Illuminator



Photomicro Illuminator



Opti-Lume Illuminator

High intensity monochromatic light . . . instant choice of bright field, dark field or polarized light . . . general purpose illumination for visual observation or photomicrography—whatever your requirement, there's a Bausch & Lomb illuminator to fill it *exactly*.

***. . . with science's most complete line!***

Only Bausch & Lomb provides such a wide range of highest quality micro-illuminators for every phase of microscopy . . . and every budget!

***WRITE*** for informative Catalog D-119. Also, on your request, we'll gladly check your present micro-illumination methods for correctness. No obligation, of course. Write to Bausch & Lomb Optical Co., 77108 St. Paul Street, Rochester 2, New York.

**Bausch & Lomb *Microscope* Illuminators**

THE
SCIENTIFIC MONTHLY
AUGUST 1952

# Methodology Conference of the Central Statistical Administration, USSR

A TWO-DAY conference on methodology was held at the Central Statistical Administration of the USSR in Moscow on February 20–21, 1950. I first learned of this conference in the fall of 1951, shortly before leaving the United States on a trip that was to include attendance at the International Statistical Conferences in India in December. Two reports of the Moscow conference were brought to my attention at that time: an account in *Statisticky Zpravodja* ("Statistical Bulletin"), published by the Central Statistical Office of Czechoslovakia, October 15, 1950 (p. 253, ff.); and a similar account in *Vestnik Statistiki* ("Statistical Herald"), published by the Central Statistical Office of the Ukrainian SSR, No. 1, 1950. Unpublished English-language translations of both these accounts subsequently became available in Washington. In the English translations both accounts appeared to be identical as to substance and to differ only in minor particulars, which could be attributed to the succession of linguistic transmutations through which they had separately passed. The issue of *Statisticky Zpravodja* containing the account of the conference, however, also included appended materials not contained in the Ukrainian publication. Since the two sources were consistent, and since neither seemed demonstrably superior or more reliable, I felt at liberty to quote from both in papers which I was then preparing for the Indian meetings.*

On my return to the United States following the meetings in India, I learned that an account of the Moscow conference had also appeared in *Vestnik Statistiki*, published in Moscow by the Central Statistical Administration of the USSR ([1], 88–94 [1950]). This official USSR account of the conference is, of course, the most authoritative, and for this reason I arranged for a review of the translations I had used in preparing my papers and for their comparison with the original Russian text. This review and the consequent authentication of a definitive translation were undertaken at my request by E. M. Kulischer, with the assistance of Irwin Weil. They have assured me that the English text appearing below is in all respects an accurate

* These papers were (1) "Address by the President of the International Statistical Institute at the Opening of the Twenty-seventh Session, New Delhi, December 5, 1951;" and (2) "Statistical Conceptions in the Soviet Union Examined from Generally Accepted Viewpoints." Both will be published in the *Proceedings* of the International Statistical Conferences, India, 1951. Pending publication, the contributed paper has been printed in the United States, by permission, in the *Review of Economics and Statistics* (Feb. 1952) and in the *Congressional Record* (Apr. 16, 1952).

and reliable version of the official account as it appeared in *Vestnik Statistiki* of the USSR.

I hope that this explanation will account satisfactorily for the inevitable differences in phrasing between the text here given† and the passages that I have quoted elsewhere from the other translations.

STUART A. RICE

*Executive Office of the President*
*Bureau of the Budget*

---

ON FEBRUARY 20 and 21 a conference was held in the Central Statistical Administration of the USSR on the theoretical bases of statistics.

Comrade V. N. Starovskiy, head of the Central Statistical Office, opened the conference. He pointed out that the Central Statistical Office attaches very great importance to the question of the theoretical basis of statistics because this question is very important to the further development of Soviet statistical science, as well as for the solution of an urgent series of problems that the Party and the government have submitted to the Central Statistical Office.

Our Soviet statistics is based on the great works of Lenin and Stalin and is the most progressive statistics in the world, solving complex scientific and practical problems that are much above the level and resources of bourgeois statistics. Soviet statistics, thanks to the help and guidance given it by the Communist Party, the Soviet government, and Comrade Stalin personally, has every means for further development and perfection, and for solving the problems that our Soviet activities set before statistical science.

He stated that harmful bourgeois influences and anti-Marxist distortion have come into Soviet statistical science and literature, and are hampering its development. One of the most prominent of these distortions is the formal mathematics school of thought which, he asserted, considers statistics a universal science suitable for the study of nature and society, and based ultimately on the mathematical law of large numbers and not on Marxist-Leninist theory. He said that a distortion of statistics is shown also by the efforts of some economist-statisticians to deny the validity of general principles and methods of statistics in an attempt to reduce statistics to a system of individual indexes. Starovskiy identified the main obstacle to the development of statistical science as the formal mathematical school of thought as reflected to a very large extent in a series of textbooks and teaching manuals issued both before World War II and in later years. The teaching of statistics in universities and technicums, he continued, is conducted along lines and with textbooks based on incorrect theoretical approaches isolated from the tasks proposed for Soviet statistics by the Communist Party and the Soviet government.

Comrade V. A. Sobol′, member of the staff of the Central Statistical Administration, gave a report on the theoretical basis of statistics. A résumé of his report follows.

Statistics is a social science. Studying social economic phenomena and processes, types, and forms of processes, statistics expresses them with the aid of numerical data properly compiled and processed on the basis of a thoroughgoing analysis of socioeconomic relationships.

The tasks of statistics and the theoretical foundation of statistical methods have been formulated in the works of Lenin and Stalin; their instructions are the theoretical basis of statistics.

"Statistics," Lenin teaches, "must illustrate what has been established by a thoroughgoing analysis of socioeconomic relationships and should not become an end in itself." (V. I. Lenin. *Works,* 4th ed., Vol. 3, 443.)

In a socialist society statistics is used for the planned direction of the economy with the purpose of building a Communist society. Lenin said, "In a capitalist society statistics was the exclusive province of government employees or narrow specialists; we must bring it to the masses, and popularize it so that working people themselves may gradually learn to understand how much they must work and how much they can rest, and so that a comparison of the results of the work of individual communes may become a subject of general interest and study." (V. I. Lenin. *Works,* 3rd. ed., Vol. 22, 456.)

At the 13th Congress of the Russian Communist Party, Stalin said: "Construction, government work, and planning would be unthinkable without accurate accounting, and accounting is unthinkable without statistics. Without statistics accounting would not advance a single step." (J. Stalin. *Works,* Vol. 6, 214.)

† Translated from *Vestnik Statistiki,* organ of the Central Statistical Administration attached to the USSR Council of Ministers, (1), 88–94, (1950). This translation is being published simultaneously in the June–July issue of the *American Statistician,* official news publication of the American Statistical Association, an affiliated society of the AAAS.

Soviet statistics serves as a weapon in the struggle for building a Communist society. By revealing unutilized reserves, by statistically verifying the progress of fulfillment of the national economic plan, and by working out the statistical materials needed by the Party and the government, statistics participates in the effort to build a Communist society with the utmost speed.

Statistics employs the theses of Marxism-Leninism in the concrete area of determining the statistical indexes of social development, and works out its own particular scientific laws and theoretical principles.

With Marxist-Leninist theory of social development as a basis, and proceeding from the nature of the social phenomena and processes subject to accounting, statistics establishes the scientific basis for (*a*) working out a program of statistical indexes; (*b*) observation and registration (accounting) of social phenomena, in particular working out scientific methods of selective observation; (*c*) checking and verifying accounting and report data; (*d*) grouping and collating statistical data; and (*e*) analysis of statistical data and comparison of statistical data with plan goals.

Only statistics based on historical materialism and political economy is scientific statistics.

Bourgeois economists and statisticians consider the theory of probability the theoretical basis of socioeconomic statistics, since, in their opinion, the phenomena of social life are unique, have accidental causes, and hence can be investigated only with the aid of the theory of probability.

Bourgeois scholars view statistics as a universal science outside history and equally comprehending both nature and society. This theory has been propagandized in Soviet literature in the statistical textbooks of Boyarskiy, Yastremskiy, and others. From this theory arose the so-called theory of the dying-out of statistics in a socialist society. Since, in a socialist society, development is carried out according to plan, and not on the basis of the laws of accidental clashes of the individual aspirations of members of a capitalist society, then, in the opinion of the aforementioned "theorists," in a socialist society the subject of statistics, and hence statistics itself, disappear.

Incorrect views on the subject and method of statistics have recently been most clearly expressed by Academician V. S. Nemchinov. He writes: "Statistics is the science of the quantitative [numerical] study of mass [varying] phenomena to show their qualitative uniqueness and also to determine the influence of the conditions objectively causing the variation in importance and size of the characteristics being studied." According to Nemchinov, the theoretical basis of statistics is the law of large numbers, which, in his opinion, "is as important to statistics as the law of universal gravitation is to celestial mechanics; hence, without its exact mathematical formulas the theory of statistics cannot be well founded."

Nemchinov believes that mass phenomena with varying characteristics, therefore relating to any field of nature or social life, are a subject for statistics. This thesis is fundamentally in conflict with Marxism. Marx, Engels, Lenin, and Stalin have always emphasized the uniqueness of social phenomena and their basic difference from natural phenomena. Nemchinov, however, unites the "mass" phenomena of nature and society and makes them the subject of one science, statistics. Thus, statistics, according to him, is a universal science studying both natural and social phenomena. This is a repetition of bourgeois views having nothing in common with Marxism. In addition, he maintains that the law of large numbers lies at the basis of the theory of statistics.

Thus Nemchinov, in opposition to Marxism, asserts that the theory of the science which examines social phenomena is based on the purely mathematical "law of large numbers." This shows that in this question he repeats the deductions and fallacies of bourgeois science.

The fallacy of turning statistics into a universal science was clearly revealed in Nemchinov's comments on Academician Lysenko's biological thesis report at the 6 August 1948 session of the All-Union Academy of Agricultural Sciences imeni V. I. Lenin. Nemchinov said that, from his point of view as a statistician, "the chromosome theory of heredity was part of the gold reserves of the science of mankind" (*O polozhenii v biologicheskoynauke*, Sel'khozgiz, 1948, p. 472). In his concluding remarks Lysenko made the following very correct and important observation, which has direct bearing on statistics:

> On the whole, according to the followers of Morgan, living nature is a chaos of random, separate phenomena without any essential connection or orderliness. Chance governs all.
>
> Not being in a position to show the orderliness of living nature, the Morganists have to resort to the theory of probability and, not understanding the concrete nature of biological processes, they turn biology into bare statistics. It is quite proper that foreign statisticians—Galton, Pearson, and now Fisher and Wright—are also considered the founders of Mendelism-Morganism. It is probably for the same reason that Nemchinov stated here that to him, as a statistician, the chromosome theory easily fits in with his concepts.

This clearly shows that there are no grounds for turning statistics into a universal science.

Under "Statistics" in *Bol'shaya Sovetskaya Entsiklopediya* (Vol. 52, pp. 743–44, 1947) Comrade Pisarev gives a definition of statistics which is very close to that of Nemchinov. Pisarev writes: "Statistics is an independent science with its own object (mass phenomena) and its own methods" and "The mass phenomena of nature and society are studied with the aid of statistics."

The formal mathematics school of thought in statistics is a holdover from bourgeois antiscientific ideology and is harmful to Soviet statistical theory and practice. The bourgeois theory that mathematical patterns of the theory of probability, the law of large numbers, are the basis of statistics, diverts practical statisticians from the economic analysis of statistical indexes and from establishing what these indexes should correctly contain. On the other hand, without working out scientific statistical methods based on Marxism-Leninism and without submitting problems to mathematical analysis, mathematical procedure cannot be employed with any degree of success to solve practical statistical problems.

Socioeconomic statistics based on Marxist-Leninist teachings on society solve many specific problems concerned with the calculation of statistical indexes. The theory of probability and other mathematical tools are employed in the solution of some of these problems. The use of mathematics is called for by the problems being solved by statistics and is wholly dependent on social and economic analysis.

In economic colleges and technicums instruction in mathematics should be such that students will fully master the branches of mathematics most widely used in statistics.

In teaching, until now, statistics has meant the "general theory of statistics," an eclectic jumble of theory of probability and a few theses of socioeconomic statistics. Teaching of statistics must be reorganized to make the theory of socioeconomic statistics serve as a theoretical basis for the statistics of branches of the national economy and culture.

Marxist-Leninist theory of social development must be used as the basis for working out a program of social and economic statistics and organizing an appropriate textbook. In the program and textbook, social and economic statistics must be presented as a united science embracing general statistical principles and methods, the system of indexes of the socialist national economy and culture, and the history of statistics.

Soviet statisticians must be first-class economists and active builders of Communist society rather than nonparticipating recorders of phenomena. The task of Soviet statisticians is to perform all their work in such a way as to participate actively in the magnificent effort of the Soviet people to build a Communist society. Soviet statisticians must be educated in a spirit of unlimited devotion to the Communist Party headed by the great Stalin, in the spirit of Soviet patriotism, and unlimited devotion to their country.

This role can be fulfilled if Soviet statisticians will root out the remnants of bourgeois ideology from statistical theory, develop statistical theory and practice on the basis of the teachings of Marx, Engels, Lenin, and Stalin, and improve and perfect the practice of Soviet statistics along the lines indicated by the Party and the government.

The report of Comrade Sobol' provoked lively discussion. Comrade N. G. Mikhaylov stated that bourgeois theories of statistics were being defended and propagated by enemies of the people who functioned on the planning and statistical boards. Comrade Mikhaylov believes that chiefly under the slogan of defense of mathematics in statistics, under the watchword of the law of large numbers, some of the Soviet statisticians are now trying to bring in bourgeois views on statistics. These promulgators of bourgeois theories reduce statistics to accounting, rob it of its scientific importance, and understand the connection between political economy and statistics accordingly in a bourgeois manner. Distortions of this kind, according to Comrade Mikhaylov, are to be found in a series of published articles and works of Comrades Nemchinov, Boyarskiy, Yastremsky, Pisarev, Ostroumov, Livshitz, Druzhinin, Kreinin, Ryabushkin, and others.

Comrade Mikhaylov also assailed those statisticians who deny the need for studying individual phenomena and assert that only in the mass, only in large numbers, are laws manifest. Also, in the opinion of Comrade Mikhaylov, the claim regarding the existence of special statistical laws is incorrect and injurious.

Comrade A. I. Ivanov (Statistical Administration, RSFSR) started with an account of the statements of Lenin and Stalin regarding the significance of statistics in the building of socialism. He then attempted a definition of statistics. He believes that statistics must give a clear, objective reply, founded on accounting of mass data, to all the questions raised by analysis.

Statistics studies complex phenomena on a mass scale, phenomena that are changing comparatively rapidly. In this vein he continued: They can be studied only by an organized collective of statistical

research workers. . . . Statistics studies, primarily, the phenomena and processes of social life. It has its own principles on which it operates: its basis is the theory of statistical observation, the theory of numerical representation, the theory of statistical grouping, and the theory of statistical analysis. From the results of statistical analysis and the characteristics of phenomena and processes it is possible to discover laws and connections that cannot be determined except by statistics.

Comrade T. A. Goryanov (Central Statistical Administration, USSR) said that the discussion had determined that statistics is a social, class, and Party science, that the theoretical basis of statistics, as of social science, is dialectical and historical materialism and Marxist-Leninist political economy. This thesis is recognized by all, or almost all, Soviet statisticians. In the opinion of Comrade Goryanov, however, it was shown in the course of the discussion that there still remain many theoretical questions to be solved on which Soviet statisticians are split into two opposing camps: the statisticians consistently defending the Marxist-Leninist position, and the statisticians headed by Nemchinov and Pisarev, who up to now have been defending the bourgeois formalistic position and are under the influence of bourgeois statistical theory. Empirical statisticians are also close to this school of thought. Goryanov agreed basically with Sobol"s definition of statistics and stated that of Nemchinov in his textbook on agricultural statistics is erroneous. In their recently published works, Nemchinov and Pisarev have not fully disclosed the roots of their erroneous positions on this subject, and their admission of errors is only formal. Goryanov termed Ivanov's statements at this conference incorrect; they are objectively directed as a defense of the formal mathematics distortions in statistics.

Comrade V. D. Chermenskiy (Central Statistical Administration) believes that the three principal questions of statistical theory are: what is the basis of statistical science, what is the subject of statistics, what is the method of statistics? Statistics is a social, Party, and class science. This means that the scientific basis of statistics cannot be the law of large numbers; its basis is dialectical and historical materialism, and Marxist political economy. Chermenskiy stated that various authors of statistical textbooks are mistaken in considering the theory of probability the basis of statistics; this is mathematics and not statistics. In his opinion it is also incorrect to organize the teaching of statistics into two independent, completely separate courses, so-called theoretical statistics and economic statistics. It is time to create a unified course and a unified program of the theory of statistics as a social science. Since statistics is a social science, it is incorrect to think that the subjects of its study are the mass phenomena of nature and society, as bourgeois statisticians maintain, and as certain Soviet statisticians think. Statistics differs from political economy in that political economy has to do with the theoretical analysis of social phenomena, whereas statistics has to do with a specific thoroughgoing analysis of economic relationships, including the study of individual facts and kinds of social and economic phenomena of various individual countries. The basis of the statistical method is thoroughgoing analysis of social and economic phenomena, analysis preceding statistical observation. This analysis is at the basis of grouping and is the essence of statistical study of any particular problem.

Comrade A. M. Bryanskiy (Central Statistical Administration, USSR) began with a rather short summary of the discussion on problems of statistics. He termed it characteristic and significant that the adherents of the formal mathematics school have settled, for the most part, in colleges and technicums, and in general have been people who are cut off from practical work in the field of statistics. He agreed with the basic theses of Sobol"s report, but he stated that certain additions should be made to it: The scope of the phenomena covered by statistics must be determined more clearly. The selective method of checking the quality of production in industry cannot be considered a statistical method. It is a mathematical method based on the use of the theory of probability. Bryanskiy stated further that the relationship between statistics and accounting should be clarified, and that statistics should not be called a form of accounting, although it has an effect on operational technical accounting and to a lesser extent on bookkeeping.

Bryanskiy declared that the task of accounting is to determine social and economic phenomena and processes, especially the movement of economic values, whereas the task of statistics as such is the utilization, by proper processing, of accounting data, for a thoroughgoing analysis of the processes taking place in society. Accounting determines these data, and statistics works them up and interprets them. Bryanskiy suggested replacing the term "statistical observation" with the term "statistical accounting." He stated that the Marxist dialectical method should be more clearly emphasized as the cognitive basis of statistics.

Comrade G. A. Podvarkov (Moscow Economics and Statistics Institute) averred that it is danger-

ous to exclude nature and its laws as a subject to be studied by Soviet statistics. The laws of development of productive forces presuppose, and do not exclude, in his opinion, investigation of the laws of nature and their management with the aid of statistics—a mighty tool of knowledge. Efforts to improve mathematical techniques in scientific statistics are meeting tremendous resistance, which is dangerous, because in "combatting" mathematical formalism modern statistical techniques are discarded, as if the techniques belonged to bourgeois statistics and were inapplicable under Soviet conditions. The basic field of application of statistics is social and industrial relationships. Soviet statistical science, a mighty instrument of knowledge, is being more and more widely employed in the most diverse fields of activity and in investigating economic, biological, physical, chemical, technical, and other phenomena and processes of all kinds; with the aid of statistics their characteristic orderliness is observed, revealed, changed, and subordinated to conscious action and management. Comrade Podvarkov believes that the various concrete branches of knowledge depend on statistics as a scientific instrument of comprehension and use statistical methods for studying material processes which are reflected in those branches of science, and studying laws intrinsic to material processes. Soviet statistics has been developed into a science of methods of studying and measuring the complex connections and interdependence of material phenomena and processes with the purpose of perceiving the objective laws of nature and social development and controlling these laws in the interests of building Communism.

Comrade N. Ya. Vorob'yev (Central Statistical Administration, USSR) stated that Podvarkov's statements were incorrect and in defense of the formal mathematics bourgeois school of thought which ignores the rich experience of our statistical practice and the achievements of our Soviet statistics—achievements which the statistics of the bourgeois falsifiers cannot have and have not had. He agreed with the basic theses of Sobol"s report and said that statisticians still do not study the works of Lenin and Stalin enough. These works contain penetrating theoretical theses and practical instructions on statistics. Vorob'yev agreed with Bryanskiy's observations on the relationship of accounting and statistics. Statistics, having made use of accounting data and having worked out the data in proper fashion, helps perfect and improve all aspects of accounting. At the same time, he termed incorrect Bryanskiy's statement that the role and importance of censuses and of accounting all at one time will decline in the future and that observation all at one time will be more and more replaced by systematic bookkeeping. Both the census, and accounting all at one time, will play an important role in the future. The exposure of bourgeois influences in statistics must be carried through to the end. All theoretical and practical statisticians who are dedicated to the work of Lenin and Stalin must be united to perfect further our Soviet statistics, which operates in the service of the Soviet people. They must be united for solving the tasks of constructing Communism in our country.

Comrade L. D. Yaroshenko (Moscow Oblast Statistical Administration) said that the report [of the conference] should state that the subject under discussion is the theoretical basis of Soviet statistics and not statistics in general, and also that statistics is not only a tool of knowledge, but a tool for the remaking of society, and that this last-mentioned fact is the principal one in the definition of statistics. On the question of the relationship between political economy and statistics, Comrade Yaroshenko thinks that statistics without political economy is "a game of numbers." He said that Soviet economists have not yet revealed the economic laws governing the relationships, under socialist conditions, between the funds of socialist reproduction; between accumulation and consumption, between the accumulation used for development of production of producers' goods and that used for development of the production of consumers' goods. Statistics can and should provide the material necessary for the correct theoretical solution of these problems.

Comrade S. P. Partigul (Central Statistical Administration, USSR) felt that Podvarkov was actually defending the bourgeois position on statistics. He said: The adherents of bourgeois concepts of statistical theory are now ready to admit in words that the basis of statistics is Marxist dialectics and political economy. However, in substance, as is evident from recently published textbooks and especially from the remarks of Podvarkov, the formalists have not renounced their concept of statistics as a universal science based on the law of large numbers, which studies by mathematical methods conformity to law by society and nature. Podvarkov, like other proponents of this school of thought, denies the thesis that statistics is a social science. At the basis of the formalist theories is the thesis concerning the existence of special statistical laws intrinsic to all mass phenomena. This is a typically bourgeois concept, placing mathematical laws and social laws in opposition to each other, and replacing economic analysis by mathematical procedures.

Partigul further stated that recognition of statistical adherence to law makes for errors in textbooks and works on the theory of statistics. Thus, for example, Boyarskiy and others think that only those phenomena that allow variation can be the subject of statistics. This essentially liquidationist point of view rules out the economic phenomena of a socialist society as a subject for statistics.

Comrade A. D. Dmitriyev (Central Statistical Administration, USSR) thinks that both Nemchinov and Pisarev, even in their recently published works, have treated incorrectly the connection between political economy and statistics as the most important question in a Marxist-Leninist theory of statistics. Contrary to bourgeois theory, which explains statistics as a universal and nonhistorical science for every sphere of knowledge, the basis of which is the law of large numbers, Marxist-Leninist theory looks upon statistics as a class, Party, and social science, as a historical science whose intellectual basis is dialectical and historical materialism and Marxist-Leninist political economy. Soviet proponents of the "universal" theory of statistics, he said, avoid real Marxist criticism of the basis and theses of bourgeois statistical theory. Certain of them who regard statistics as a universal method or a universal science, while speaking against bourgeois theory, quietly borrow its procedure themselves, including the method of splitting phenomena up into the simplest elements. In their works this usually takes the form of the method of a formal homogeneous aggregate, the elements of which have one thing in common. In his remarks Dmitriyev criticizes the work of Nemchinov, Livshitz, Ostroumov, Yezhov, and others, who, in his opinion, replace social and economic statistics by a universal or "pure" nonhistorical theory of statistics.

Comrade I. Yu. Pisarev (Central Statistical Administration, USSR) whose printed works and oral statements were severely criticized at the methodology conference, acknowledged that this criticism was basically correct. He also acknowledged the basic correctness of the theses of Sobol"s report. The criticism of the so-called universal theory of statistics, which he himself supported and developed, showed him that this had been a gross error on his part. Pisarev discussed his premises, which had led him to defend the course on the general theory of statistics. He promised to correct his errors and to give an exhaustive criticism of the universal theory of statistics on the basis of Marxist-Leninist classics on statistics.

Comrade N. P. Titel'baum (Central Statistical Administration, USSR) thinks the basic theses of Sobol"s report are correct. Statistics is a social science, the basis of which is materialistic dialectics and political economy, and the subject of which is socioeconomic phenomena and processes. In his opinion, the struggle with bourgeois manifestations in statistics must not only be conducted against universal statistics. There are bourgeois statisticians who reject the theory of universal statistics, but who at the same time adhere to positions of formalistic, idealistic, non-Marxist statistics, divorced from specific knowledge of economic processes and phenomena. Bare statistics—i.e., formalistic statistics—breaking down the form and content of the phenomena being studied in all branches of human knowledge, is unnecessary and harmful. In Titel'baum's opinion, Sobol"s statement about the need for opposing the formal mathematics school of thought in statistics contains a threat of rejecting mathematics generally, the threat of disarming statistics of mathematical procedure. It is therefore necessary to speak of opposing the formalist, not the formal mathematical school of thought, in statistics. With regard to the methods of statistical observation, the position should be clearly formulated that the chief method of statistical observation in the Soviet economy is that of reports which must be put ahead of other methods—census, observation all at one time, etc.

The place of a course on statistics of branches of the economy in a general unified course on the theory of statistics is not treated in Sobol"s report. This is very important in making teaching plans and in drawing up programs for our educational institutions. This problem must be worked out.

Comrade I. S. Malyshev (Central Statistical Administration, USSR) spoke primarily about incorrect statements made at the methodological conference. Yaroshenko, he said, incorrectly asserted that arguments about the content of statistical theory are abstract and not related to practice. On the contrary, he said, delaying the solution of important theoretical problems of statistics can only hamper further improvement of statistical work.

Malyshev was also dissatisfied with the statements of Pisarev, who talked more about the merits and advantages of so-called universal statistics than about what is wrong and bourgeois in this theory. The fact that all bourgeois statisticians uphold the universal theory is all the more reason why Pisarev should give a serious Party criticism of universal statistics. It is absolutely necessary to do away with the bourgeois "universal" theory of statistics if an end is to be put to formalism in the theory of sta-

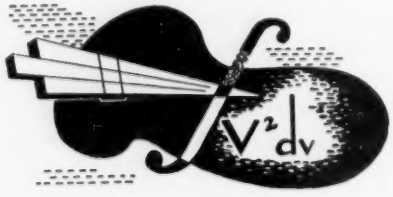
tistics. In order that the "universal" theory of statistics might be given the appearance of a science, it is supported by the law of large numbers, whose meaning in this field depends on such and such phenomena being counted, on the average being computed, and laws determined. If we take the viewpoint of a "universal" statistic which examines all manifestations in social life, in physics, chemistry, biology, and any other field, then it will be common to all manifestations that they can be computed and mathematically processed, and therefore—say the apostles of the universal theory of statistics—the basis of statistics is the theory of probability, the law of large numbers, and statistics is a branch of mathematics used for every sphere of human activity. These theories contradict the statements of the founders of Marxism-Leninism on the subject and method of statistics as a social, Party science. In its decree on the reorganization of the Central Statistical Administration, USSR, the Soviet government determined the tasks of all state statistics, tasks which are the basic theoretical and practical work of all statisticians of our country.

Proponents of the universal statistics, indeed, try to transform the theory of statistics into an abstract scheme divorced from practical activity, divest it of a Party character, and separate statistical science from sharp practical problems of our socialist construction. They are trying to prepare cadres incorrectly in our educational institutions.

We statisticians, Malyshev said, should actively assist our Party and government in the building of a Communist society, and actively combat any attempts at bourgeois distortion of the theory and practice of Soviet statistics. The Central Statistical Administration has acted quite correctly in approving a new program on the theory of statistics and in deciding to make up a new textbook on the theory of statistics, he said.

Comrade Sobol′ summarized the two-day discussion. The first conclusion which must be drawn, he said, is that some statisticians still cling to wrong views on theoretical problems of statistics. This is borne out by the statements of Podvarkov, who has tried to speak against the basic themes of Marxist-Leninist theory on statistics as a social science. The second conclusion is that there are several adherents of the formal mathematics school of thought who, although they have not rejected their views, in contrast to Podvarkov have shrunk from defending their theoretical positions in open discussion. The third conclusion is that a new program on statistics must be set up in colleges and technicums, and new textbooks presenting the correct Marxist-Leninist theory of statistics must be written.

Summarizing the conference, Comrade Starovskiy said that the conference unanimously condemned the bourgeois distortion which has penetrated textbooks and programs on statistics, and condemned the universal theory of statistics and the divorcing of scientific work on statistics from the practical tasks of socialist construction. As Stalin teaches us, he stated, statisticians must be, above all, first-class economists. Starovskiy stressed the need to get down immediately to the practical work of preparing sound programs and textbooks on statistics for colleges and technicums, and summoned statistical workers to friendly teamwork in carrying out the instructions of the Party, of the government, and of Stalin personally on the tasks of state statistics.



# Form and Function: A Problem in Biophysics*

MAX A. LAUFFER

*Dr. Lauffer (Ph.D., Minnesota, 1937) has been research professor of biophysics and head of the Department of Biophysics at the University of Pittsburgh since 1949. Before that he was with the Rockefeller Institute, Princeton, New Jersey. In July he left for a six-months stay in Europe, where he will be the guest of the Theodor Kocher Institute of the University of Bern, Switzerland.*

IMPLIED in the decline of vitalism is the hope, if not the belief, that life processes can ultimately be explained in terms of physical and chemical mechanisms. The proposition that specific biological functions are associated with specific physical structures, or combinations of specific physical structures, is essential to such a view. Hence, if biophysics is to deal with key problems in biology, it must be concerned with the relationship between form and function.

The word "form" has many meanings. For present purposes, form can be defined as "a physical body with recognizable shape and structure." Philosophers frequently ascribe quite a different meaning to this word; this is one reason for being so careful in stating precisely what is meant. The word "function" presents less difficulty; a satisfactory definition is "the natural, proper, or characteristic action of anything; especially, the normal and special action of any organ or part of a living animal or plant."

When one tries to consider the general problem of the characteristic actions of organs or bodies with definite shape and structure, he must cover a great deal of territory. At the macroscopic level, there is the entire subject matter normally included in the disciplines of morphology and physiology. At the microscopic level, this subject deals with the specific biological roles of definite physical entities; for example, pathogenesis by bacteria, and the respiratory function of erythrocytes. At the submicroscopic, or macromolecular, level it deals with such problems as the relationship of the etiology of virus infections to characteristic virus particles, the relationship of the toxic action produced in living tissues to crystalline toxin proteins, or the relationship of catalytic action on specific chemical reactions to crystalline enzyme protein molecules. At the molecular level it deals with the relationship between physiological effects and specific chemical structures of well-characterized molecules.

It is evident that it is not possible to deal with very many aspects of so inclusive a subject in a short discussion. For this reason, the present discourse is limited to just one aspect: "How can one identify function with form?" Biologists and biochemists have wrestled with this problem at its various levels for many years and have developed a variety of techniques, each suited to particular kinds of problems. If there is any virtue in the present effort, it is that it might possibly represent a point of view that leads to a solution of some generality.

First, let us examine a few of the techniques in common use. At the level of gross morphology, it is frequently possible to observe a form while it functions. This is an obvious, direct, and unambiguous way of associating form with function. The same method can sometimes be used at the microscopic level. An example in point is the malarial parasite. One can actually watch with a microscope while this parasite develops inside red blood cells, and can verify for himself that the periodic elevations of temperature associated with malaria are directly correlated with the release of these parasites from the blood cells.

This direct method cannot always be used, however. Bacteriologists customarily use a method formulated by Koch. If a body—for example, a bacterium—is to be regarded as an etiologic agent, first it must be demonstrated that the particular bacterium is always associated with some particular disease. Second, the organism must be propa-

* Publication No. 12 of the Department of Biophysics, University of Pittsburgh.

gated on artificial media. Third, the artificially grown organism must produce the characteristic disease in an experimental host. Finally, the organism must be reisolated from this host. If all these criteria can be met, then the bacteriologist is willing to say that the organism produces the disease. In essence, what these four steps do is establish universality of association between the form—that is, the organism—and the function—that is, disease production—and to render unlikely the possibility that some other masked or hidden form is responsible for the function. This is a necessary and practically sufficient basis for ascribing the function to the form.

At the molecular level, the process of identifying form with function is somewhat similar. Take, for example, the identification of the intoxicating principle with the chemical molecule ethyl alcohol. It has been known for centuries that certain beverages have the common property of being intoxicating. It has been demonstrated that all these beverages contain a particular chemical compound, ethyl alcohol. Ethyl alcohol can be isolated, purified, and tested for purity. The most highly purified preparation possible to obtain can then be demonstrated to cause intoxication. Therefore, chemists are willing to conclude that the intoxicating principle common to all these beverages is a property of the chemical compound of known structure, ethyl alcohol.† The basis of their evidence is universality of association and, at least to a degree satisfying to biochemists, absence of other common structures.

Intentionally postponed until last is a consideration of the problem at the macromolecular, or submicroscopic, level. How does one establish the relationship between the etiologic agent of a virus disease and the particles which can be isolated and even pictured with the electron microscope? The way most people attempt to establish this relationship is similar to the chemist's method just outlined. First, it is shown that the particles are always associated with the disease. Next, preparations of these particles are obtained from diseased tissues, purified, and then tested for purity. Finally, the purified material is used to produce disease in a new host, and the particles are again isolated from this new host. In my view, however, this procedure does not constitute sufficient evidence of association of form with function in the case of viruses.

Why, it might be asked, is a method good enough in the simple chemical case not good enough in this case? The reason is that the action of molecules like ethyl alcohol is statistical; the over-all effect is the net result of the simultaneous action of an almost unbelievably large number of molecules. The possibility simply does not occur to biochemists that some trace contaminant in the ethyl alcohol might be the true agent of intoxication. Infection by a virus, on the other hand, is more like a quantum phenomenon. Although a very large number of virus infectious units are usually contained in an infectious dose, nevertheless, all the evidence that can be brought to bear indicates that the infection is actually initiated by a single one of these entities. The only function served by the large number of units is to increase to some reasonable value the probability that at least one of the units will actually produce an infection.[1] In a situation like this, the danger seems very real indeed that some minor contaminant present to the extent of one part in a hundred, or even one part in a thousand, might be the real etiologic agent, and that the highly purified preparation of particles might be merely some extraneous substance without function which happens always to be present. This unhappy possibility has made it seem to the author necessary to seek a more nearly foolproof method of identifying form with function.

A fundamentally new approach to this problem is suggested by the operational philosophy described so well by Bridgman.[2] The essence of operationalism, as I understand it, is that an entity or a concept should be defined in terms of the operations used to obtain evidence concerning it. When this point of view is applied, one realizes that two kinds of experiments are done by investigators in the field of virus research.

In one kind, susceptible hosts are used to determine what happens to the virus material when it is given some experimental treatment. Operationally, such experiments provide information concerning a biologically active or an infectious entity. The intellectual climate of contemporary science is such that the assumption is made almost automatically that the infectious entity is some physical or material body. Thus, the infectious entity is, by assumption, a form, but a form the physical nature of which may be unknown. By definition, however, the infectious entity is that which possesses the function—disease production in this case.

Other kinds of experiments are done in which

† This identification of function with form does not imply direct action. In the particular example chosen, it is currently held that an oxidation product formed after ingestion is an essential intermediate in the production of the effect. Nevertheless, it is the ethyl alcohol in the beverage, neither water nor any other molecule present in it, which is responsible, even though indirectly, for the intoxication.

physical or chemical observations are employed to find out what happens to the virus material when it is treated. Operationally, such experiments provide information about a characteristic particle or molecule. The characteristic particle is, by definition, a form. Usually, the physical nature of this form is partially known, for it is recognized in the first place by virtue of such physical characteristics as electron microscope image and sedimentation rate in the ultracentrifuge.

It is thus consistent with operationalism to recognize that our experiments provide information about two entities, one an infectious entity and the other a physical entity or characteristic particle. The question of associating function with form now becomes a problem of investigating the identity of two forms, one of them an operationally defined physical entity which can be visualized, and the other an operationally defined biological entity, which is, therefore, by definition, the agent associated with the function.

The identity of an infectious entity, or, more generally, a functional entity, with a characteristic particle can be investigated by demonstrating coincidences in properties of the two. In general, one can measure with considerable precision properties or parameters of physical entities by physical means. Let us suppose that it is also possible to measure various properties or parameters of the infectious entity with reasonable precision. If the infectious entity is the same as the characteristic particle, then the magnitude measured of the particular parameter of the infectious entity should be the same within experimental error as that of the corresponding parameter for the characteristic particle. Suppose two different magnitudes or properties or parameters of each are measured. Then, again, the two numbers characteristic of the infectious entity will each be identical within experimental error with its counterpart measured for the characteristic particle, if the biological and the physical entities are the same. The point to all this is that a relatively small number of coincidences in magnitude of parameters determined for an infectious entity, with comparable parameters determined for the characteristic particle, can serve to establish, beyond any reasonable doubt, the identity of the infectious entity and the characteristic particle.

Epstein and Lauffer have recently completed a study designed to show how this type of approach can be used to settle the question of the relationship of the infectious entity to the characteristic particles of Southern bean mosaic virus protein.[3] Several years ago, Price[4] showed that a nucleoprotein could be isolated from bean plants diseased with this virus and that this nucleoprotein preparation was capable of infecting other plants. The protein can be obtained in crystalline form and has a molecular weight of around 6 million.[5, 6] The molecules of this protein can be photographed with the electron microscope. They are essentially spherical bodies about 30 mμ in diameter.[7] An electron micrograph of Southern bean mosaic virus characteristic particles is shown in Figure 1. These

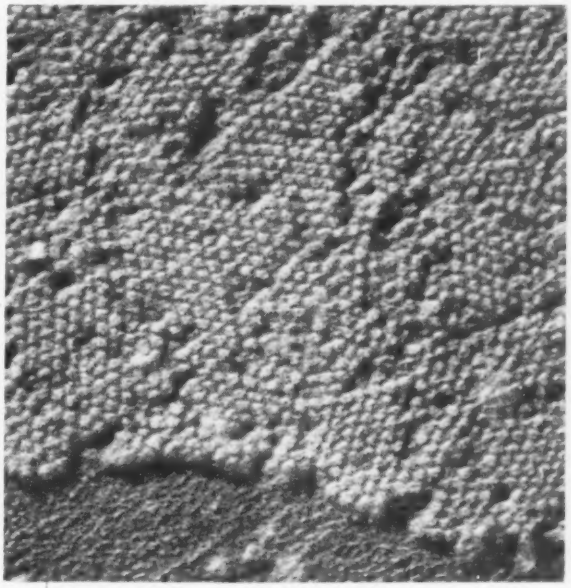


FIG. 1. Electron micrograph of Southern bean mosaic virus protein characteristic particles shadowed with uranium at an angle of 76°. ×70,000. (Micrograph prepared by T. R. Padden.)

nucleoprotein molecules are the characteristic particles of Southern bean mosaic virus, and they have been considered, on the basis of much evidence, as being the bodies which actually bear virus infectivity. The problem attacked by Epstein and Lauffer was the investigation, through this favorable medium, of methods of establishing appropriate coincidences.

The ultracentrifuge provides a very convenient method for carrying out such identification. The sedimentation rate of the characteristic particle can be determined quite easily by strictly physical methods. The material is put in the centrifuge cell, and the migration of the characteristic particle is followed optically. Figure 2 shows a typical optical record actually obtained in an experiment of this sort. Such experiments yield information about the sedimentation rate of the characteristic particle. The sedimentation rate depends upon the difference between the density of the particle and the

density of the medium surrounding it;‡ hence, sedimentation rates can be decreased by increasing the density of the medium—for example, by adding sucrose. In this way, the sedimentation rates of the characteristic particle under a variety of conditions can be obtained. At first, one might think that a large number of parameters characteristic of the particle can be obtained by doing a large number of experiments of this sort. However, sedimentation rate is essentially a linear function of the density of the suspending medium. Since a straight line can be characterized by only two parameters, intercept and slope, sedimentation constants of particles in media of different densities can really determine only two fundamental parameters of a particle. In any case, from such experiments, two parameters,§ or constants, descriptive of the characteristic particle of Southern bean mosaic virus can be and were obtained.[3]

It is also possible to use the ultracentrifuge to determine the sedimentation rate of the infectious entity. To do this it is necessary to have some biological method of following the events in the centrifuge cell. A cell is available for the ultracentrifuge which has two compartments separated by a perforated barrier on which a tiny piece of filter paper can be placed.[8] This cell, known as a separation cell, is illustrated in Figure 3. In an experiment the cell is filled with the virus preparation. When the centrifuge is operated, the infectious entity sediments toward the bottom and passes through the filter paper on the perforated barrier. After the centrifuge is stopped, the contents of the compartment above the barrier can be removed and tested for ability to produce disease. If the centrifuge has been run only long enough to allow the infectious entities originally at the top of the cell to sediment halfway to the barrier, or even nine tenths of the way, the contents of this compartment will produce infection. If, however, the centrifuge has been run exactly long enough to allow even the originally most distant infectious entities to have sedimented just through the barrier, then the contents of the top compartment will no longer produce infection.

‡ To a fair approximation, the sedimentation behavior of Southern bean mosaic virus protein in sucrose solutions of different densities obeys an equation of the form $\eta s = \phi (d-d_o)/f'$, where $\eta$ and $d_o$ are the viscosity and the density of the solution, and $s$ is the sedimentation velocity of the virus characteristic particle per unit field. In the ideal case, $\phi$ is the hydrodynamic volume, $d$ is the over-all density, and $f'$ is a shape factor of the virus particle.[6]

§ From the preceding footnote it is evident that these parameters are $\phi/f'$ and $d$. It must be emphasized, however, that only as an ideal can the parameters be given the physical interpretation previously suggested.[6] Nevertheless, the parameters are characteristics descriptive of the behavior of the material in the ultracentrifuge.

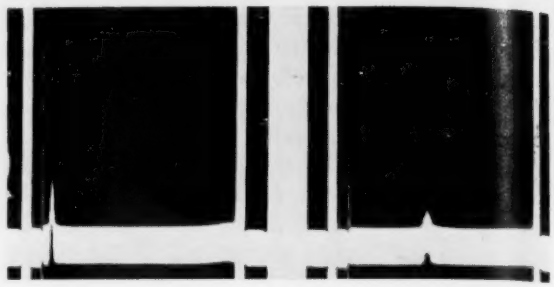


FIG. 2. Optical record obtained in sedimentation experiment on Southern bean mosaic virus protein (×1.75). Left, at beginning of experiment; right, after 16 minutes of sedimentation at a speed of 24,630 rpm. The spike is a plot of refractive index gradient, which is proportional to concentration gradient, against distance from the center of rotation, and it represents the sedimenting boundary between Southern bean mosaic virus protein and solvent. From the displacement of the spike, the time interval between exposures, and the speed and radius of the centrifuge, the sedimentation rate can be calculated.

The experiment thus consists of running the centrifuge for varying times and in this way finding the time that it takes for all the infectious material to just leave the top compartment. Since the dimensions of the top compartment are known, it is a simple matter to calculate the sedimentation rate of the sedimenting material. Such a sedimentation rate is observed by biological methods; therefore the rate is characteristic of the biological entity or the infectious entity. These experiments can be repeated with media of different densities, too, and again two fundamental parameters descriptive of the infectious entity can be evaluated. These two parameters for the infectious entity of Southern bean mosaic virus were estimated with a maximum error of 10 per cent, and, within that error, they were identical with the corresponding two parameters for the characteristic particle.[3] Thus two coincidences between properties of the infectious entity and the characteristic particle have been established.

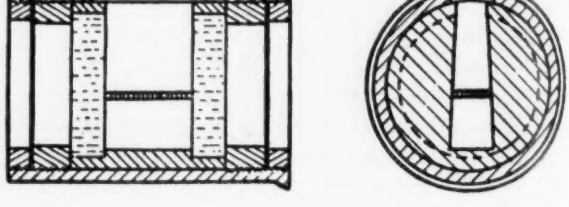


FIG. 3. Longitudinal and cross-sectional views of the separation cell.

Other methods of establishing fundamental coincidences between parameters of biological or functional entities and those of physical entities are being investigated in the Department of Biophysics at the University of Pittsburgh. The methods of diffusion and electrophoresis offer promise. The difficulty is that precision is sometimes difficult to obtain in experiments in which biological measurements are used to follow what is happening. It is possible, however, that ultimately as many as ten independent parameters can be evaluated for an infectious or functional entity, with an error of the order of 10 per cent. The corresponding constants for the characteristic particles can already be evaluated with much better precision than that. Ultimately it should be possible to reduce the probability of purely accidental association to a very low value.

The beauty of this method of approach, as I see it, is that it can be applied quite generally to the problem of associating function with form. One can always define the biological or functional entity as that which possesses the function, and one can usually devise methods of determining some physical and chemical properties of that biological entity. Then one can also characterize the physical entity or the form by physical and chemical means. If enough coincidences are established, an extremely strong case can be made for the identity of the biological or functional entity and the characteristic particle or the form. And this amounts to the same thing as having identified a function with a form.

In my view, this method of approach does not share some of the limitations of previous methods. Both the method of the biochemist and the method of the bacteriologist rely strongly upon evidence of purity and the assumption that any small amount of impurity that might be present is not really responsible for the function. The operational approach described here circumvents entirely considerations of this sort and is therefore a better method than those in common use.

One of the most important lateral developments is the possibility of determining enough parameters of a biological or functional entity to permit one to draw an accurate physical picture of the object, even though the material has never been isolated and purified. As an illustration, sedimentation and diffusion constants could, in principle, be obtained for any virus infectious entity present in crude tissue extract. This amount of information would be sufficient to permit the determination of the size and shape of the virus infectious entity. In the past, biochemists and biophysicists have been chained to the necessity of isolating, purifying, and characterizing so-called active components of tissue in order to investigate the mechanisms of biological systems. With our method, it would be possible to do any of these things without going to the trouble of isolating and purifying. In some instances, biologically active principles are present in such minute quantities that isolation and purification are major obstacles. Particularly in such instances, the short cut afforded by the present approach would be most helpful.

The application of the operational point of view to the problem of associating form and function is so appealing that it seems unlikely that it is original. Possibly one of the hundreds of persons who have had to wrestle with the question of associating function with form has thought of this. Undoubtedly many have used methods that in practice amount to the same thing. It is hoped that this presentation will entice others to try this approach in the analysis and solution of their own problems in biology.

### References


1. Lauffer, M. A., and Price, W. C. *Arch. Biochem.*, 8, 449 (1945).
2. Bridgman, P. W. *The Logic of Modern Physics.* New York: Macmillan (1927).
3. Epstein, H. T., and Lauffer, M. A. *Arch. Biochem. Biophys.*, **36**, 371 (1952).
4. Price, W. C. *Am. J. Botany*, **33**, 45 (1946).
5. Miller, G. L., and Price, W. C. *Arch. Biochem.*, **10**, 467 (1946).
6. Lauffer, M. A., Taylor, N. W., and Wunder, C. C. *Arch. Biochem. Biophys.* (in press).
7. Price, W. C., Williams, R. C. and Wyckoff, R. W. G. *Arch. Biochem.*, **9**, 175 (1946).
8. Tiselius, A., Pedersen, K. O., and Svedberg, T. *Nature*, **140**, 848 (1937).

# Some Implications of Multiple-Purpose River Planning and Development*

MORRIS LLEWELLYN COOKE

*Morris Cooke, a consulting engineer in management, located in Philadelphia, writes against the background of a long career in public service. He was director of the Department of Public Works in Philadelphia, 1911–15; chairman, Storage Section, War Industries Board, 1917; executive assistant to the chairman, U.S. Shipping Board, 1918; chairman, Mississippi Valley Commission, Public Works Administration, 1933; director, Water Resources Section, National Resources Board, 1934; and administrator, Rural Electrification Administration, 1935–37. Following the completion of these tasks, he filled many other responsible government posts, and in 1950–51 was chairman of the President's Water Resources Policy Commission. He has been an author and an editor, and is the recipient of many honors, including the French Legion of Honor.*

THE concept of multiple-purpose river development necessarily calls for the meticulous husbanding of the basin's waters and the socially most desirable use of the included land areas. A study of the applicable literature would lead one to believe that all that is needed is a faithful observance of the involved scientific-engineering considerations. As a matter of fact, there are legal, managerial, ethical, and social implications which, unobserved, may more than offset the results of the most enlightened technical approach. My object is to discuss some of the implications of effective river development not usually given much weight by the technicians.

## First Essential

For instance, an inescapable step in bringing about uniformity and efficiency in such developments is the appointment of a Federal Board of Review authorized by Congress and located in the executive office of the President, or detached, as is the Federal Reserve Board. This board would seek to put on a comparable basis the work of the agencies set up in individual river basins. Some "grass-roots" representation is a first essential of such regional commissions. The Board of Review would establish standards for authorization of projects, for evaluation and reimbursement, for costs and accounting, and provide for their uniform application throughout the nation. It would conduct a continuing study of all applicable legislation, sponsor remedial changes, and provide the President and the Congress with information respecting all phases of federal participation.

To be effective, the Board of Review should have a distinguished status, with its five or more members receiving salaries of $15,000–$20,000 during a ten- to fifteen-year term of office, subject to confirmation by the Senate and removable only on proved charges of improper conduct. The recommended high status is warranted both by the paramount importance of the field to be covered and by the size of financial outlays that would come under the board's supervision—currently a billion dollars a year. Created under adequate legislation, a Board of Review could eliminate fairly promptly a large part of the waste and irrationalities that plague this area of federal effort at present.

Such a top-level agency has received widespread endorsement from interested individuals and groups, notably from the Hoover Commission, an agency created by Congress. More than 175 years have elapsed since this idea of a central clearing-house was born, for we read in an 1825 publication: "As there was at that time [*ca.* 1776] no board established for internal improvements, of the kind, the [American] Philosophical Society was the natural repository of all the ideas suggested by ingenious men on the subject."[1]

Questions as to the qualifications, technical and

* Based on an address given in the Symposium on "The Nation's Water: Want, Waste and Why?" during the Annual Meeting of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE in Philadelphia, Pa., December 26–31, 1951.

otherwise, of the members of such a Board of Review are difficult and have led to a wide difference of opinion. In an amendment offered—but not adopted—to the Rivers and Harbors Bill (*Public Law 516*) Senator O'Mahoney called for a board consisting of an all-engineering group, whereas Senator Douglas' bill (S. 3657) does not suggest qualifications. Another authority thinks members "should have widely recognized standing in public affairs and be deeply interested in water conservation and use." President Truman, recognizing that water and associated land problems involve—in addition to the obvious engineering factors—scientific, social, political and economic considerations, appointed to the President's seven-man Water Resources Policy Commission a geographer, a biochemist, an agricultural economist, two engineers, and two economists. The unanimous report of this commission well illustrates the value of the interplay between representatives of different professional disciplines.

As time goes on there will be fewer and fewer commissions set up to report on matters usually considered as engineering, to which only engineers will be appointed. This will happen whoever does the selecting and whether the subject to be investigated lies within the public or the private domain. Even businessmen will come to see that the specialized viewpoint and the factual outlook of the engineer need the complementary services of those skilled in other disciplines. Reciprocally, commissions appointed to consider matters not heretofore considered as lying within the engineering field are likely to have engineers included in their membership.

### Standards and Their Utilization

The status of standardization in river work, both as to the standards themselves and the practices through which they are made effective as carried on, for example, by the Army Engineers and the Bureau of Reclamation, which do the bulk of this work, appears to be at a relatively low level as compared with that obtaining quite generally in the execution of other types of public and private engineering work.

Many years ago, responsibility for highway construction afforded my first introduction to the conditions that must surround public work, for efficiency and economy and, quite as important, to have it honestly and ethically conducted. In those early days we bought pavements under trade names such as Amiesite, Vibrolithic, and Bitulithic. These were superseded by materials described by formulas indicating ingredients, just as Schenck's Mandrake Pills and Perry Davis' Pain Killer have given way to remedies with the contents listed on the bottle. Then came opening tenders in a public assembly room, with the bids written immediately on a blackboard for all to see, followed by awards to the lowest responsible bidder, with responsibility clearly defined. The process was one of constant improvement in our standards, increasing clarity in our specifications, and almost day-to-day betterments in the procedures for estimating, inviting bids, awarding contracts, and inspecting the work. Less and less the organization depended on oral instruction. *"An executive decision is only a moment in process. The growth of a decision, the accumulation of authority, not the final step, is what we most need to study."*[2]

A system such as the one described, to operate in the public interest, requires an educated body of substantial contractors as contrasted with the fly-by-night type, who are usually only too politically minded. A fully standardized system automatically weeds out inefficient employees or those who do not want to cooperate. Furthermore, any citizen, under our standardized regime, could get for the asking an answer to his question as to how this, that, or the other thing was done. The time of top officials was thus made available for handling the exceptional tasks and for long-range planning.

The process toward standardization in highway work has gone forward in the interval in hundreds of places—in municipalities, townships, counties, and states—and, broadly speaking, under the cooperating leadership of the U. S. Bureau of Public Roads and the American Association of State Highway Officials. Obviously, the level of accomplishment varies as between places, but within surprisingly narrow limits. The State Highway Officials have a score of standing committees covering every conceivable aspect of highway work, each with membership from every state and territory and a secretary from the Bureau of Public Roads. Handbooks are printed at short intervals, with mimeographed bulletins showing the interim changes. The handbook on traffic-control devices runs to 233 pages. All these publications are available to the public.

It might be thought that highway work, seemingly involving simpler types of engineering, might be more amenable to standardization than river work. However, urban road work may normally average $500,000 a mile and in tough situations reach 5 millions and over. The psychological hazards of dealing with the whims of the owners of 52 million motor vehicles, each fully competent to render judgments, possibly helps to balance the

scales. At any rate, science teaches that even highly complicated work can be reduced to routine.

As one observes the operations of both Reclamation and Army Engineers, standardization does not appear to have progressed very far except as to a few detailed technical matters. Departmental "doctrine" and the ipse dixit of the top man still bar out the reign of carefully developed managerial law. Under an adequately standardized system, to "throw" a contract to a particular contractor, whatever the motive, is demoralizing, no matter who authorizes it. So, also, is the practice of awarding a contract for one amount of work and later authorizing additions far in excess of the original contract award.

Army Engineers and Reclamation have through recent years been bitterly embroiled in plans for the development of the Missouri River, which obviously require more water for their execution than would normally be available. Standardized practice and more basic data would have suggested a relatively easy arithmetical showdown and the arbitration of differences. Then in 1944 came the threat in Congress of a Missouri Valley Authority, and overnight the battle flags were ostentatiously furled (but with no change whatever in the plans of either organization so far as the public has been advised). In fact, feuding between these agencies is widespread and continuous—and quite naturally, because they are employed on comparable work but under radically different legislative instructions.

The use by the Reclamation Service of inflated power rates as justifying dams built to further irrigation, a practice which was never really justified, becomes increasingly demoralizing with the decrease in the number of acreages suitable for sound irrigation projects. The continued use of the "interest component," a factor so flexible in its application as to have no engineering or economic significance, is doing irreparable harm to the interests of the dry West.

There doubtless remain sound irrigation possibilities. But the present unwise method of justification does not in application demonstrate their soundness. Current techniques are frequently used to justify ill-conceived and hastily planned projects. Report has it that at this moment ten dams in the arid West stand idle either because there is no water behind them or because the farmers will not use the available water. These dams are mute monuments to a variety of furtive subsidies.

Stream areas represent, say, 1 per cent of land areas, so that 99 per cent of our rain falls on land over which neither Reclamation nor Army Engineers have any sort of jurisdiction. Not only is neither agency uneasy over this situation, but they both act in opposition to the Department of Agriculture in its efforts to effect those upstream controls without which ever-increasing floods are the inevitable outcome.

The highly successful drive toward standardization in TVA operations has doubtless been assisted by the fact that the Authority has jurisdiction over the land areas within the Tennessee basin and further by the building of twenty dams—six on the main stream—and six large steam plants, all within a closely confined watershed, in an eighteen-year period, and with a fresh and carefully chosen staff. (Perhaps I owe it to anxious engineering friends to say that standardization should not be allowed to block improvement.)

### Military Control of Public Works

The river work of the Army Engineers is conducted by its Civil Works Division, but with the top control wholly in military hands. The civilian engineers attached to the Engineer Corps, although almost wholly responsible for design and construction, cannot aspire to the top positions where recommendations and decisions are made. This fact undoubtedly affects not only the morale of the organization but has an influence on the character and quality of those who enter this branch of the public service.

It seems hardly feasible to construct peacetime public works economically and efficiently under a type of command designed to get results in military operations. "The Engineering Manual for Civil Works has been prescribed in the official orders and regulations for the Corps of Engineers as the basic guide for the planning and construction of civil works projects. This manual has been in preparation for more than 7 years and is far from completion."[3] This seems a bit deliberate even for a military organization. Then, too, the periodic movement of officers in charge, essential in a military system fitted to meet constantly changing field conditions, is disastrous in an organization operating in fairly static situations.

American industry, and management generally, have been getting completely away from military types of control, largely under the inspiration of the teachings of Frederick W. Taylor.[4]

### Costs

Means for determining costs is an absolute necessity in most standardized managerial processes. Accurate costs should influence river work at every stage. The Army Engineers, who through

the years have been distinguished for the cordiality of their relations with Congress, suffered a shock recently when a subcommittee of the House Appropriations Committee charged that Corps construction costs have "increased inordinately." The subcommittee looked into why costs of 182 projects are now some 124 per cent above the original estimates. Fifty-four per cent of the 124 per cent gain, totaling about $800,000,000, was termed "attributable to insufficient engineering planning and estimating," which, if true, undoubtedly means an inadequate cost system.

Cost determinations as used in preliminary estimates must be so designed as to permit constantly increasing details as the work and the need develop. TVA, in publishing costs on all its major projects, is setting a standard never heretofore achieved by any public or private agency. All records are kept in accord with the FPC uniform system. Dependable costs in the absence of regularized managerial practices are impossible.

### Government by Crony

In the execution of federal public works the political scientist envisions, as quite distinct and separate entities, first, the Congress authorizing and making appropriations; second, a department of the government having supervision of the class of work involved; and, finally, a contractor executing tasks for the public. These agencies in theory are thought of as being constantly alerted to the need for maintaining the niceties of ethical behavior while necessarily cooperating in the execution of public tasks. Over considerable areas involving many millions of dollars of expenditures, however, this is not at all the situation. Through a maze of trade associations, each effectively organized to exert pressure for public funds for particular varieties of public work, it is easy to detect a close, and quite frequently clandestine, blending of public and private interests, in which the maintenance of ethical standards is usually all but impossible. These uncharted relationships have persisted through the years, quite irrespective of which political party happened to be in power.

When I was holding public office, some years ago, it was suggested to me by William J. Burns, the well-known detective, that I avoid lunching or dining (he called it "mealing") with anyone with whom I was having dealings on behalf of the public. Some years later, when making an official call on a member of President Coolidge's cabinet, I recalled this sage advice. My mission was to advise Secretary Blank that some of his departmental employees were making uncalled for, if not illicit, concessions to certain private interests. Pretending to be irritated, the Secretary said rather vehemently, "You cannot buy my people!" And then after a pause he added, "But you can buy them a dinner." The influence of this type of informal fraternizing is frequently potent where the actual tender of articles of value would fail. One prominent federal official recently told me that having his residence outside Washington made it easier to avoid informal evening gatherings away from his office, where his variety of public business might be discussed.

### The Engineer's Attitude Toward Society

As making plans for river developments and their execution is almost exclusively in the hands of engineers, the social outlook of the profession as contrasted with its technical competence is important. Every variety of planning in a democracy has its social as well as its technical values. Even the height of a dam may have social significance. The fact that possibly a majority of the whole body of civil engineers is in the public service affords no guarantee in this matter, because employment by government does not necessarily imply social-mindedness. But the fact that 86 per cent of all engineers have employee status, either in private enterprise or in government service, doubtless has some bearing.

The content of almost any branch of engineering has become so expansive that the education of the engineer is normally a four-year grind devoted to the study of technical subjects. Among the professions, the engineer is the only one who has not had the benefit of some schooling in the humanities and public causes. Faced with the seeming necessities of the normal four-year course, the responsibly advocated campaign for the inclusion in engineering curricula of 20 per cent of cultural studies has made relatively little progress.

With this educational background, the engineer lives in his technical ivory tower hardly cognizant of the pulsating world around him. He is generally quite reluctant to get into the hurly-burly of community and political life, and frequently is quite inept when he does so.

C. J. Mackenzie, the distinguished engineer who is now president of Atomic Energy of Canada Limited, has said:

> It is not uncommon to observe men who, having achieved marked success and reputation in a specialized professional business or industrial field, assume that their opinions are of equal validity in public affairs. This is one of the weaknesses of our present-day democracies. As Rebecca West so well puts it, "The study of physics or chemistry is no more likely than the study of harmony or counterpoint to develop social omniscience.". . .

It is discouraging to hear—as one does occasionally—engineers and scientists with little experience or background in political affairs suggest that a certain baffling social problem could be solved quite simply if it were only left to engineers who, presumably by applying the laws of physical science, would readily find a workable solution. . . . As engineers, we should never make the rather stupid error of assuming that human actions follow valid and consistent laws such as we have in our fields of physical science.[5]

The foregoing has a rather obvious bearing on the content and quality of the report which the Engineers Joint Council, through the cooperation of some 80 individual engineers under distinguished leadership, drafted for the guidance of the President's Water Resources Policy Commission. It bears as well on their 233-page critique of the commission's report, recently widely distributed.[6]

Let me cite just one all-important clear-cut point at issue. The President's Commission advocated in every appropriate situation financial statements based unequivocally on facts, with nothing hidden. But in certain cases, contrary to the counsels of the EJC, it advocated going a step beyond the relatively simple factors used by the banker responsible for the soundness of his loans. For we are building and maintaining a nation. Here the peace, progress, and happiness of individuals are the desiderata. In analyzing a certain type of regional situation, the commission advocated supplementing the carefully determined financial outlook with a factually based economic investigation. Without at times obtaining this broadened view, and acting on it, there may be nothing to retard the normal drift whereby relatively strong localities, regions, and states become ever stronger while the less strong grow constantly weaker in such matters as education, health, agricultural and industrial development, and other factors affecting the good life and the national welfare. A balance in sectional economies—not necessarily uniformity, of course—is in the national interest.

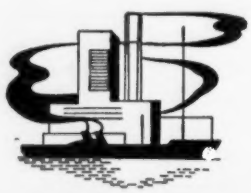
Firmly fixed habits of both government and banking are such that supplementary economic analyses are rarely provided for. The motivation of the priority of personal profit is too strong. It is therefore a responsibility of engineers as citizens to save the employer from his neglect, and to include in his analysis and estimate total costs and benefits, economic and social, as well as purely engineering. As citizens, we engineers should be realistic and not hide behind a theoretical concept of the division of labor.

This all adds up to the fact that "An increasingly complex society makes it impossible to segregate science and technology from their human and social consequences,"[7] and so perhaps it is always a mistake to "confuse engineering skills with social and political philosophy."

As we balance all the factors, favorable and unfavorable, in the field of water and its allied land uses, the result world-wise and nation-wise is none too promising. Competent authorities are holding that this way lies our doom. Most such prophesying is based on the prospect that sinful man will be as profligate of water in the future as he has been in the past, and that he will not take advantage of the multiplying means for husbanding this absolutely crucial resource. As fear itself is all we have to fear, I ally myself with the hopefuls. But in doing so I recognize that there must be widespread rededication.

### Bibliography and Notes


1. Sioussat, St. G. L. *Proc. Am. Phil. Soc.*, 95, (3), (June 1951).
2. Follett, M. P. The Illusion of Final Authority. *Taylor Soc. Bull.*
3. From a report of the House Appropriations Subcommittee on Army Civil Functions, John Kerr, of N. C., chairman (Aug. 16, 1951).
4. National Planning Association. Causes of Industrial Peace, a series of studies on the operation of American industrial plants.
5. Quoted from *The Engineer and his Community* by C. J. Mackenzie in the Roy V. Wright Lecture, Semi-annual Meeting, Am. Soc. Mechan. Engrs., Toronto, (June 11–15, 1951).
6. Apparently there are to be two schools of thought within the engineering profession with respect to the PWRPC report, as evidenced by two recent editorials: *Elec. World* (Nov. 5, 1951); and *Eng. News-Record* (Nov. 8, 1951).
7. Larkin, J. D. Quoted by B. Fine in Educated Americans or Trained Robots? *Ethyl News* (Oct. 1951); Brownell, B. Are Engineers Educated? *Northwestern Engr.* (Dec. 1943).

# The Cause of the Great Ice Ages

KARL A. PAULY

*Karl A. Pauly has completed a career as an electrical engineer. A graduate of MIT, he spent his last sixteen years before retirement as managing engineer of GE's Industrial Divisions, and geology was merely a hobby. Even though* THE SCIENTIFIC MONTHLY'S *editorial advisers do not concede that Mr. Pauly has proved A. S. Eddington's thesis of a shift in the earth's crust, they believe he has developed an approach—obvious but new—to a critical analysis of glacial chronology in earth history. Use of his method may result in acceptance of the Eddington hypothesis, but it is too soon to reach that conclusion yet.*

IN A paper entitled "The Borderland of Geology and Astronomy," A. S. Eddington suggested that the Great Ice Ages were caused by shifting of the earth's outer crust, over the interior, as a result of tidal friction. Under the influence of tidal friction alone the lithosphere would drift in an east-west direction, but Eddington also suggested that its course might be altered by excessive local friction between it and the substratum caused by buckling of the lithosphere. Because of my intense interest in the subject, I undertook to determine whether Eddington's hypothesis might be correct.

Soon after beginning this study, I became convinced (1) that the unsymmetrical locations of the continental ice sheets with respect to the earth's poles preclude the assumption that they were caused by shifting of the earth's axis with respect to the ecliptic, or by a general lowering of the temperature of the earth as a whole; (2) that the ice sheets were not the result of abnormal local conditions, since the time required to produce the great ice caps must have been far longer than it is reasonable to assume that the necessary abnormalities could exist. Also, the contemporary changes in the climates of many widely scattered localities indicated that the cause or causes which brought about the conditions that produced the ice sheets were world-wide in their effects.

Because of these limitations, I felt that all the theories that had been proposed to explain the causes of the Great Ice Ages were inadequate. On the other hand, the Eddington hypothesis seemed free from any of these limitations.

As information concerning the Pleistocene Ice Age is vastly more complete and definite than that of the earlier glacial periods, I chose it for my study. A brief review of Pleistocene glaciations will provide essential orientation for the discussion that follows.

Canada was completely, or nearly completely, covered by the Keewatin and Labradorian ice sheets. The Keewatin, with center just west of Hudson Bay, extended south approximately to the 48th parallel; and the Labradorian, with center just east of Hudson Bay, extended south approximately to the 40th parallel. Glaciation in the cordillera and Alaska was limited, largely if not wholly, to the extension of mountain glaciers. Flint indicates that the shift from the Keewatin to the Labradorian ice sheet may have occurred during the Kansan substage.

In Europe the ice caps were confined to the northwestern section, extending east approximately to the Ural Mountains and south approximately to the 48th parallel. There were four or five distinct stages of glaciation, with centers apparently drifting in a northeasterly direction. These ice advances were separated from one another by interglacial stages. No major ice sheets were developed on the continents of the Southern Hemisphere, for reasons that will be apparent later.

If the lithosphere was displaced during the Great Ice Ages, we should expect ice sheets to develop in the polar areas with the poles at approximately their centers. I shall therefore assume that the lithosphere was so displaced during Pleistocene time, and that the North Pole lay, successively, approximately under the centers of the Pleistocene ice sheets of the Northern Hemisphere. If it can be shown that the Pleistocene latitudes of a sufficiently large number of widely distributed localities conform to these assumed displaced positions of the lithosphere, a strong, if not conclusive, case will have been made for the assumed displacement.

Although the elevations of the terminal moraines of free-flowing mountain glaciers are affected by a large number of conditions, latitude is one of the major factors. Therefore, a close approximation to

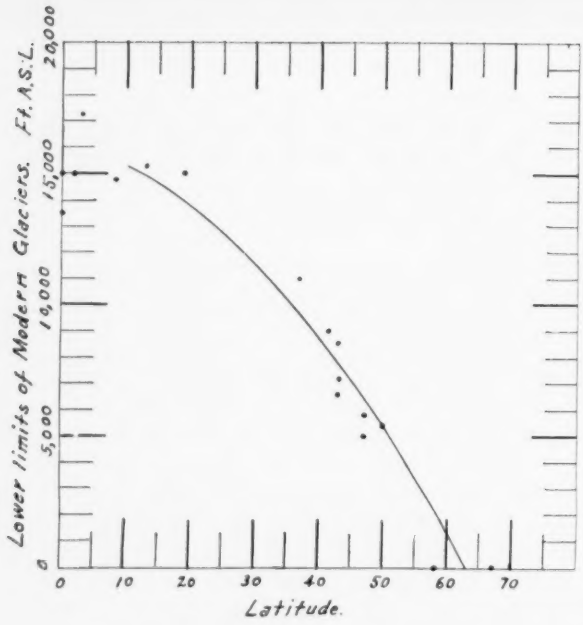



Figure 1.

a true altitudinal curve indicating the relationship between these terminal moraines and their respective latitudes can be prepared, provided this curve is based on enough points to reduce the effects of the other factors to a satisfactory degree.

Our problem, then, is reduced to the simple task of comparing the relationships between the terminal moraines of modern and Pleistocene free-flowing mountain glaciers and their respective latitudes, to determine whether systematic differences support the hypothesis of lithospheric displacement during Pleistocene time.

Figure 1 shows the relationship between the elevations of the terminals of present-day free-flowing mountain glaciers and their respective latitudes as given in Table 1.

The locations of the centers of the North American ice sheets, the Keewatin and Labradorian, and those of the second stage of the European glaciations have been quite definitely determined. The centers of the remaining European glaciations have been estimated from the limits of the glaciated areas, as indicated by Antevs:

> In Europe an eastward shifting of the Pleistocene glaciations has recently been discussed (Limonouski, 1922; also Kulozynski, 1924, pp. 181–185; Kozlovskii, 1924, p. 115). Of the assumed glaciations the first is believed to have occupied only Great Britain and Scandinavia, the second similarly only western and central Europe, the third western and central Europe as far as western Russia, and the fourth the area from the North Sea to eastern Russia. The greatest extent was reached in western Europe during the second epoch, in central Europe during the third, and in eastern Europe during the fourth.

The approximate locations of these centers are given in Table 2, in which, in the interest of brevity, they are referred to as 1N, 2N, etc.

TABLE 1

| Location | Lat. | Long. | M.T.M.* (Elevation in Feet) |
|---|---|---|---|
| *North America* | | | |
| Iztaccihautl, Mexico | 19° N | 98° W | 15,000 |
| Sierra Nevada, USA | 37° N | 120° W | 11,000 |
| Mount Shasta, USA | 42° N | 123° W | 9,000 |
| Mount Rainier, USA | 47° N | 122° W | 5,000 |
| Mountains near CPRR station, Canada | 50° N | 123° W | 5,400 |
| Taku Glacier, Canada | 58° N | 134° W | Sea level |
| *South America* | | | |
| Ecuador, central | 2° S | 77° W | 15,100 |
| Sierra Nevada de Merida, Venezeula, central | 8° N | 71° W | 14,800 |
| Sierra Nevada de Santa Marta, Colombia | 13° N | 74° W | 15,300 |
| *Europe* | | | |
| Caucasus Mountains, USSR, north side, central | 43° N | 43° E | 6,600 |
| Caucasus Mountains, USSR, south side, central | 43° N | 43° E | 8,500 |
| Pyrenees Mountains, France–Spain, central | 43° N | 0° | 7,200 |
| Rhone Glacier, Switzerland | 47° N | 8° E | 5,800 |
| Norway | 67° N | 14° E | Sea level |
| *Africa* | | | |
| Mount Ruwenzori, Belgian Congo | 0° | 30° E | 13,500 |
| Mount Kenya, Kenya Colony | 0° | 37° E | 15,000 |
| Mount Kilimanjaro, Tanganyika | 3° S | 37° E | 17,300 |

* Modern terminal moraines.

TABLE 2

| | | |
|---|---|---|
| *North America* | | |
| 1N, Keewatin glaciation center | 62° N | 100° W |
| 2N, Labradorian " " | 55° N | 68° W |
| *Atlantic Ocean* | | |
| 1A, Atlantic Ocean glaciation center | 55° N | 45° W |
| *Europe* | | |
| 1E, First stage of European glaciation | 55° N | 15° W |
| 2E, Second " " " " | 63° N | 20° E |
| 3E, Third " " " " | 70° N | 32° E |
| 4E, Fourth " " " " | 80° N | 45° E |

In determining the curve for Pleistocene mountain glaciers on the assumption that the lithosphere was so displaced that the glaciation centers, 1N, 2N, etc., lay successively over the pole, the latitude of the terminal moraine of a Pleistocene mountain glacier was its latitude when that glacier was nearest the pole. The major exceptions to this general rule would be found on the west coasts of North America and of Europe, where the climates are tempered by the Japan Current and the Gulf Stream, respectively, and where mountain glaciers reach sea level at approximately 59° N and 67° N latitudes, respectively. Therefore, it is assumed that the terminal moraines of all Pleistocene mountain glaciers were formed when their latitudes were less than 67° from the equator, although they may have been nearer a pole at some other time. At higher latitudes, glaciers would reach sea level and, therefore, leave no terminal moraine.

Table 3 gives the lower limits reached by Pleistocene mountain glaciers, and Figure 2 shows, graphically, the relationship between these limits and their respective Pleistocene latitudes. In this table I have included the approximate present locations (*Lat.* and *Long.*), Pleistocene latitudes (*Lat.'*), and elevations of the Pleistocene terminal moraines (*P.T.M.*), assuming the lithosphere shifted as indicated under *North Pole*.

It is obvious from a comparison of the curves of Figures 1 and 2 that the relationships between the elevations of the terminal moraines of Pleistocene mountain glaciers and their respective latitudes are the same as those for modern glaciers only if the poles are assumed to have shifted as indicated in Table 2. This conclusion is also supported by additional data which cannot be represented graphically, but which requires brief discussion.

The climates of North America and Europe just preceding their glaciations, and of Asia during the glaciation of North America and Europe, indicate that the glaciation of North America preceded that of Europe. If this was so, we should expect the following:

1) That the climate of North America, preceding glaciation, would gradually become colder. In support of this, Schuchert and Dunbar state, "After Eocene time there was a slow but general southward migration of the various plant assemblages, indicating a gradual cooling of the climate that became more marked in Pliocene time and culminated in the Pleistocene glaciation."

2) That the climate of Europe would be warmer than normal preceding its glaciation. This is indicated by the Pleistocene latitudes of Greenwich (51.5° N, 0°), England, which would be 39.8° N and 50.8° N with the North Pole at 1N and 2N, respectively. Bearing on this point, Geikie makes the following statement: "Before the commencement of Glacial Period Europe was in the enjoyment of delightful climate . . . certainly more genial and equable than the present" (*cf.* Fig. 3).

3) That the climate of Alaska would be warmer than normal during most of the ice age and at no time much colder than at present. Kuzetrim (65° N, 165° W), Alaska, and the approximate center of Alaska (65° N, 152° W) were 61.4° N and 67.3° N, respectively, with the North Pole at 1N, and both were nearer the equator for all other assumed positions of the lithosphere during the Pleistocene. Referring to this, Antevs states, "The conclusion has been drawn that, even when great parts of the North American continent were buried beneath ice sheets, Alaska enjoyed a milder climate than it does today and in post glacial time a de-

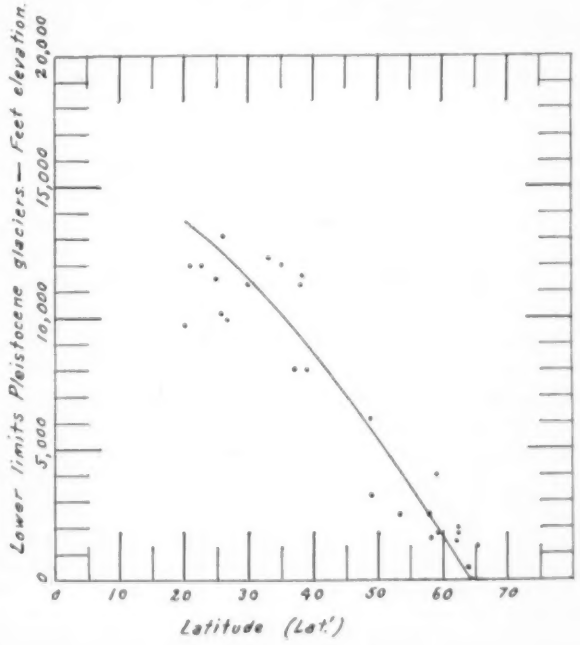



Figure 2.

TABLE 3

| Location | Lat. | Long. | North Pole | Lat.' | P.T.M. (Elevation in Feet) |
|---|---|---|---|---|---|
| *North America* | | | | | |
| Coast and Sierra Nevada ranges | 37° N | 120° W | 1N | 62.1° N | 2,000 |
| *South America* | | | | | |
| Central Ecuador | 2° S | 78° W | 2N | 32.4° N | 12,300 |
| Northern Peru | 5° S | 78° W | 2N | 29.4° N | 11,300 |
| Central " | 10° S | 75° W | 2N | 24.7° N | 11,600 |
| Southern " | 15° S | 74° W | 2N | 19.8° N | 9,700 |
| Bolivia | 18° S | 64° W | 4E | 21.0° S | 12,000 |
| Argentine, northeastern | 24° S | 60° W | 4E | 26.2° S | 13,200 |
| *Europe* | | | | | |
| Sierra de Gredos, Spain | 40° N | 5° W | 2E | 62.5° N | 1,770 |
| Mont Rotonda, Corsica | 42.5° N | 9° E | 3E | 60.1° N | 1,410 |
| Gallego Valley Glacier | | | | | |
| North side, France | 42.5° N | 0° | 3E | 58° N | 1,650 |
| South side, Spain | 42.5° N | 0° | 3E | 58° N | 2,600 |
| Lake Isceo, Italy | 46° N | 10° E | 3E | 63.7° N | Below 500 |
| Old Moselli Glacier | 48° N | 8° E | 3E | 65.2° N | 1,250 |
| *Asia* | | | | | |
| Eastern Nepal, India, center | 29° N | 86° E | 3E | 39.2° N | 8,000 |
| Valley of Sikim, India | 27.5° N | 88° E | 3E | 37.1° N | 8,000 |
| Taipai Shan, China | 34° N | 107° E | 4E | 38.1° N | 11,650 |
| Tsinling Shan, China | 34° N | 108° E | 4E | 38.0° N | 11,250 |
| Lebanon, Syria | 36° N | 36° E | 2E | 61.3° N | 4,000 |
| Thiah Shan, Mongolia, center | 42° N | 80° E | 3E | 53.3° N | 2,500 |
| Mountains near Oleminsk, Siberia | 57° N | 115° E | 4E | 59.1° N | 1,700 |
| *Africa* | | | | | |
| Mount Kenya, Kenya Colony | 0° | 38° E | 2E | 25.6° N | 10,200 |
| Mount Ruwenzori, Belgian Congo | 0° | 27° E | 2E | 26.6° N | 10,000 |
| Mount Kilimanjaro, Tanganyika | 3° S | 37° E | 2E | 22.8° N | 12,000 |
| *Australia and New Zealand* | | | | | |
| Mount Carstensz, New Guinea | 4.5° S | 138° E | 1E | 35.0° S | 12,000 |
| Mount Bogong, Victoria | 38° S | 147° E | 2E | 49.8° S | 3,200 |
| Mount Kosciusko, New South Wales | 37° S | 148° E | 2E | 49° S | 6,150 |
| Tasmania | 42° S | 146° E | 1E | 72° S | Sea level |
| New Zealand, South Island | 44° S | 170° E | 2E | 63.6° S | " " |

terioration set in causing extermination of part of the fauna and forcing the forest southward."

4) That the climate of Siberia would be warmer than normal during the glaciation of North America and the early stages of the glaciation of Europe, and that it would gradually become colder during the latter stages of the glaciation of Europe. The Pleistocene latitudes of the northern end of the Ural Mountains (68° N, 65° E), Lake Nelgato (70.5° N, 80° E), Taimyr Peninsula (76° N, 100° E), the approximate center of the New Siberian Islands (75° N, 145° E), and the approximate center of this entire group (72° N, 98° E) for different positions of the lithosphere are given in Table 4.

This conclusion is supported by Antevs' statement that fossil fauna and flora have been found far north of where they now live, at the northern end of the Ural Mountains, at Lake Nelgato, on Taimyr Peninsula, on the New Siberian Islands,

TABLE 4

| | 1N | 2N | 1A | 1E | 2E |
|---|---|---|---|---|---|
| Ural Mountains | 40.5° N | 37.8° N | 43.3° N | 52.8° N | 71.2° N |
| Lake Nelgato | 42.5° N | 37.6° N | 41.5° N | 49.7° N | 66.3° N |
| Taimyr Peninsula | 48.8° N | 41.2° N | 42.9° N | 47.4° N | 62.1° N |
| New Siberian Islands | 47.1° N | 45.2° N | 41.6° N | 49.4° N | 52.5° N |
| Approx. center of group | 44.6° N | 37.4° N | 39.6° N | 45.2° N | 61.2° N |

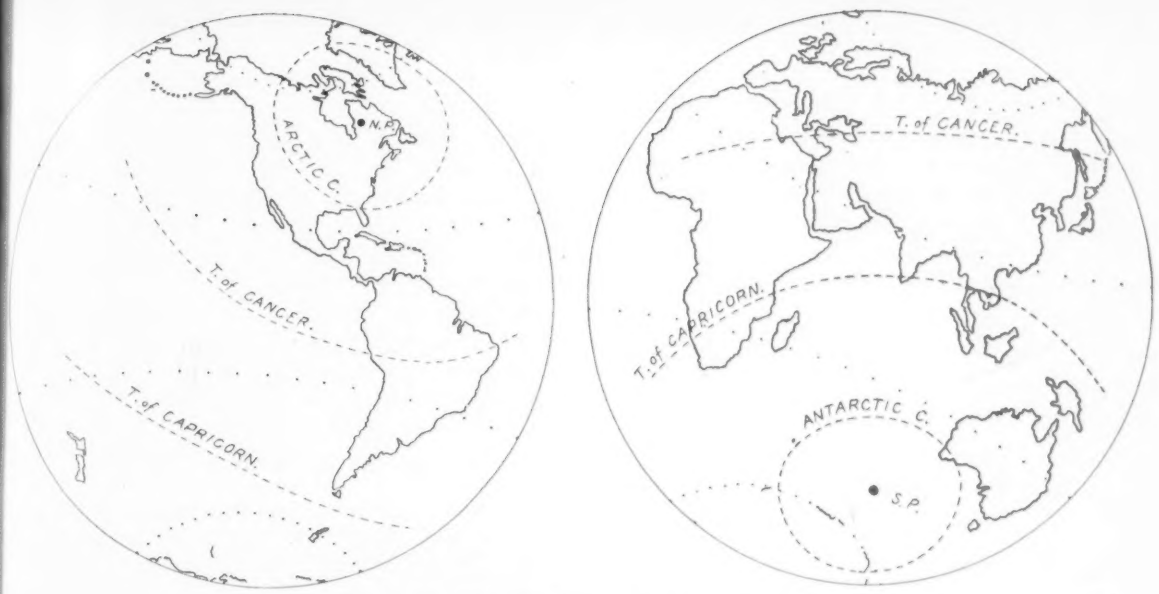



FIG. 3. Climatic zones with North Pole at 2N.

and also in a large area of northwestern Siberia.

*Europe.* With the North Pole at 2E, the latitudes of the eastern and western ends of the Caucasus Mountains (40° N to 45° N, 48° E to 38° E) were approximately 62° N and 69° N, respectively. Figure 1 indicates that we should expect Pleistocene glaciers to extend down to 750 feet and sea level, respectively. On the north side of the mountains, the Pleistocene glaciers extended 5 miles beyond the base. Unless the glacier was located at the eastern end of the chain and the foot of the mountain was at sea level, this is a very close agreement between the expected and actual elevations of the terminal moraine (*cf.* Fig. 4).

*Asia.* During Pleistocene time glaciation extended across Canada from Alaska to the Atlantic Ocean and east across northwestern Europe from Great Britian and Norway approximately to the Ural Mountains. It is, therefore, reasonable to assume that parts of the North Atlantic Ocean also lay under the North Pole at some time.

With the North Pole at 1E and 1A, the latitudes of Mount Carstensz (4.5° S, 138° E) would be approximately 35° S and 39° S, respectively. Figure 1 indicates that we should expect the elevations of the terminal moraines of its glaciers to be 10,000 and 9300 feet, respectively. The terminal moraines of Pleistocene glaciers are reported at approximately 12,000 and possibly 8500 feet. If the North Pole was at 1A before 1E we should expect to find the upper, as well as the lower, moraine preserved.

*Africa.* With the North Pole at 2E, the latitude of the Kharga Oasis, Lybian Desert (25° N, 31° E), would be approximately 51° N, or about 8° farther north than the present southern boundary of France. We should therefore expect to find a fossil flora that does not now flourish south of Corsica and the southern boundary of France, a fact reported by Hume, Craigie, and Krenkel.

With the North Pole at 3E, the latitude of the approximate center of the Great Atlas Mountains (29° N to 37° N, 11° W to 9° E), would be 48.8° N, and Figure 1 indicates that we should expect the elevation of the terminal moraine of a glacier at this location to be 5700 feet. Geikie reports that J. Hooker and Ball and Maw give 6000 feet as the elevation of the Pleistocene terminal moraines of these mountains.

*Australia.* Evidence of two or three stages of glaciation have been found on Mount Kosciusko, New South Wales (37° S, 148° E). With the North Pole at 2N, 1E, and 2E the latitudes of Mount Kosciusko would be approximately 60° S, 69° S, and 49° S, respectively. During the first stage of glaciation, the Kosciusko Plateau was covered with ice which went down to 4500 feet elevation and then spread out over an area of approximately 80–100 square miles. Figure 1 indicates that, with the North Pole at 1E, mountain glaciers would reach sea level. We should therefore expect to find a glacier with extended foot at 4500 feet elevation if conditions favored its formation, as they did in this case.

If the glaciation of Europe followed that of North America, the terminal moraine produced with the North Pole at 2N would be destroyed by

the glacier when the North Pole was at 1E; on the other hand, the terminal moraine produced when the North Pole was at 2E would remain. As Pleistocene latitude of Mount Kosciusko was 49° S at this time, the expected elevation (Fig. 1) of the terminal moraine on this mountain would be 5800 feet. The actual elevation of the upper moraine is 6150 feet. The top of Mount Kosciusko is below the expected elevations of the terminal moraines of mountain glaciers for the remainder of Pleistocene time.

Based on a similar analysis, the Pleistocene latitude of Mount Bogong with the North Pole at 2E has been included in Table 3.

With the North Pole at 1N, the latitude of Kerguelen Island, Indian Ocean (49° S, 70° E), would be 76° S. This is within, although on the outskirts of, a polar area in which we should expect an ice sheet to develop. Antevs states that Norenskjold (1907) and Krenkel (1925) reported the island entirely or almost entirely covered by an ice sheet not very long ago.

There is no positive evidence of the formation of ice sheets in the Southern Hemisphere during Pleistocene time, other than possibly on Kerguelen Island. This is as we should expect it, since, on the basis of the assumed positions of the lithosphere with respect to the North Pole, the South Pole would lie in the Pacific Ocean remote from major land areas during the entire Pleistocene Ice Age.

I shall confine my reference to the recessions of the ice during the interglacial stages or substages to a single question: May these not be accounted for by the precession of the equinoxes, or this in combination with perturbations in the earth's orbit around the sun?

The evidence that I have drawn from Pleistocene time has been confined very largely to colder-than-normal climates. I shall now present evidence taken from Trias-Jura time which is based largely on warmer-than-normal climates. In this discussion, I shall assume that the lithosphere was so displaced that the South Pole lay under the center of the Trias-Jura ice sheet.

Although the Trias-Jura Ice Age seems to have lasted a very long time, it differed from both the Pleistocene and Permo-Carboniferous ice ages in that, apparently, there existed but one great ice sheet, that of central Africa, concerning which Coleman makes the following statements:

> The most complete account of glaciation of this age has been given by two American Geologists, Ball and Shaler, from the Lualaba valley west of Lake Tanganyika in Lat. 3° 30′ to 5° south.
>
> The glacial materials came from the south and extended about 100 miles, the northern part consisting of boulders enclosed in shales.

If we assume this tillite to indicate the periphery of a great ice sheet—and this seems the most logical assumption to make—we should expect its center to be 15°–20° to the south. I have, therefore, assumed the center to be at approximately 18° S latitude and 31° E longitude, and that the South Pole lay under its center during Trias-Jura time.

The location of the Trias-Jura equator, in terms of present-day latitudes and longitudes, is given in Table 5, and the distribution of climatic zones is shown in Figure 5.




FIG. 4. Climatic zones with North Pole at 2E.

TABLE 5

| Lat. | Long. | Lat. | Long. | Lat. | Long. |
|---|---|---|---|---|---|
| 72.0° N | 31° E | 56.2° S | 150° E | 30.5° S | 70° W |
| 57.8° N | 90° E | 72.0° S | 150° W | 25.7° N | 50° W |
| 30.5° N | 110° E | 57.8° S | 90° W | 56.2° N | 30° W |
| 25.7° S | 130° E | | | 72.0° N | 31° E |

All the land areas of the earth lay between the Trias-Jura 49th north and south parallels, with the exception of about two thirds of Africa and a narrow strip of the west coast of North America beginning at Seward (60° N, 150° W), Alaska, passing near Santa Fe (36° N, 106° W), New Mexico, and ending at San Blas (22° N, 106° W) in southwestern Mexico.

The 49th parallel is the most northern boundary of the United States, exclusive of Alaska. Therefore, we should expect this entire area to be as warm as, or warmer than, the United States during Trias-Jura time. Also, all of Europe, China, Greenland, Australia, Antarctica, and South America, with the exception of the most eastern tip of Brazil (about 2° of longitude), and nearly all of Siberia lay within the Trias-Jura tropics. We should therefore expect a generally mild climate over most of the land area of the earth during Trias-Jura time, and this is exactly what occurred, as is indicated by the following quotations:

Coleman states:

> Going back in time from the Eocene, few suggestions of glaciation have been found in the Mesozoic, which seems to have been, on the whole, one of the warmest parts of the earth's history.

Schuchert and Dunbar state:

> Although the late Paleozoic was marked by extensive glaciation in many parts of the world, there can hardly be doubt that the climate was generally warm again in Triassic time and probably subtropical as far north as New England and Wyoming. This is indicated by the distribution of cold-blooded land animals. . . .
>
> If this indicates mild Triassic climate, the evidence is still more convincing for the Jurassic and much of Cretaceous time. . . .
>
> Fossil plants confirm the implications of the reptiles.

It is contended by some that the presence of coal cannot, alone, be taken as diagnostic evidence of the existence of tropical or subtropical climates at the time it was laid down because of the great evolutionary changes that have taken place in the genera of the coal-producing floras. On the other hand, there seems to be no definite evidence to the contrary.

If the lithosphere was displaced, as assumed, during Trias-Jura time, and tropical and subtropical floras were the origin of Trias-Jura coals, we should expect to find these coal deposits lying within, or just outside, the Trias-Jura tropics. I therefore determined the Trias-Jura latitudes of the Trias-Jura coal deposits as reported in *Coal Resources of the World*, and the results are given in Table 6.

Duplications in the table indicate the occurrence of deposits laid down during both the Triassic and Jurassic periods. The climates of Alaska and of western Mexico, where there are three coal deposits outside the Trias-Jura subtropics, may have been tempered by an ocean current.

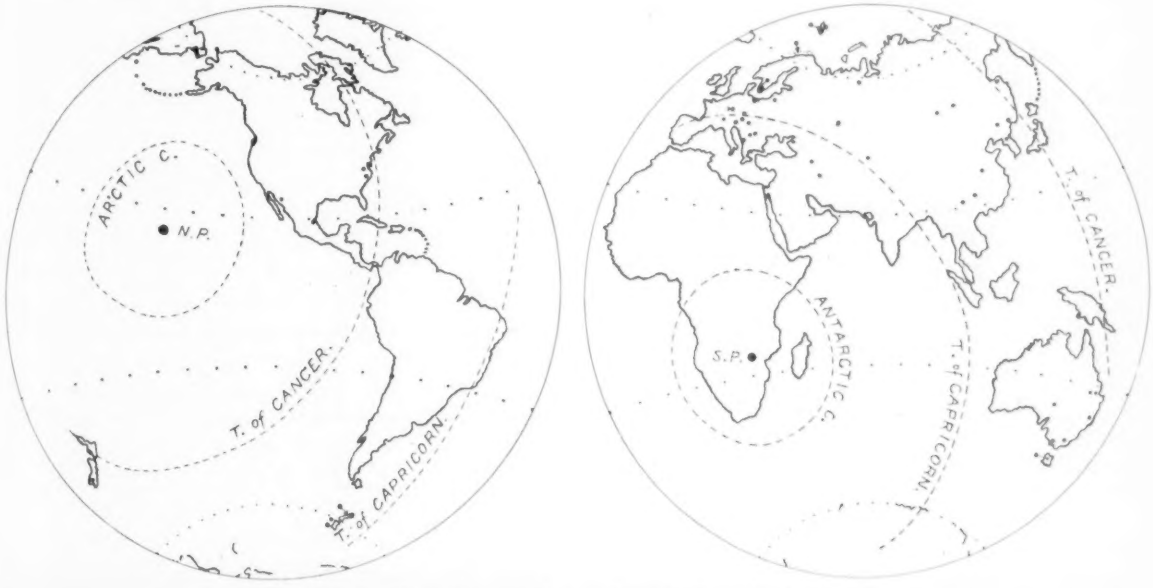



FIG. 5. Climatic zones during Triassic-Jurassic time.

TABLE 6

JURASSIC AND LIASSIC COALS

| Area | Present Location | | Jurassic Lat.' |
|---|---|---|---|
| *North America* | | | |
| Farmville and Richmond, Va., USA | 38° N | 78° W | 25.7° N* |
| Corwin District, Alaska, USA | 69° N | 165° W | 38.7° N |
| *Europe* | | | |
| Portugal, center | 41° N | 8° W | 21.0° S** |
| Caucasus Mountains, USSR, center | 40° N to 45° N | 49° E to 38° E | 29.6° S * 26.7° S |
| Serbia, northeastern part | 44° N | 21° E | 27.3° S* |
| Switzerland, center | 45° N | 8° E | 23.3° S** |
| Rumania, if south of Transylvania Alps | 45° N | 23° E | 25.9° S* |
| Hinterholz, Austria; all Austria within Trias-Jura subtropics | | | * |
| Northern and Central Alps, Austria | 47° N | 15° E | 23.3° S** |
| Hungary, center | 47° N | 19° E | 24.3° S* |
| Vosges, France | 48° N | 7° E | 20.6° S** |
| Basel, Switzerland | 48° N | 8° E | 21.2° S** |
| Bornholm Island, Denmark | 55° N | 15° E | 15.7° S** |
| Lithuania, center | 55° N | 24° E | 16.6° S** |
| Oresund, Sweden | 56° N | 26° E | 15.9° S** |
| Ural Mountains, east slope | 53° N to 68° N | 58° E to 68° E | 15.7° S ** 0.3° S |
| Advent and Sassen bays, Norway; all Norway within Trias-Jura tropics | | | ** |
| Andö Island, Norway | 70° N | 16° E | 1.9° S** |
| Spitzbergen | 78° N | 17° E | 6.7° S** |
| *Asia* | | | |
| Japan, central | 36° N | 138° E | 24.0° N* |
| Province of Nagato Phyong-an-do, Korea; all of Korea within Trias-Jura Tropics | 39° N | 126° E | 15.0° N** |
| Fergana, Turkestan | 41° N | 71° E | 20.3° S** |
| | 43° N | 131° E | 19.3° N** |
| Along shore of Sea of Japan | 54° N | 141° E | 26.7° N* |
| Chi-lin, Manchuria; all Manchuria within Trias-Jura tropics | 44° N | 126° E | 15.9° N** |
| Irkutsk, Siberia | 52° N | 104° E | 4.4° S** |
| Trans-Baikal Province, Siberia | 53° N | 113° E | 9.6° S** |
| *Australia and New Zealand* | | | |
| Queensland, southwestern | 25° S | 148° E | 16.9° N** |
| Leigh's Creek, South Australia | 30° S | 138° E | 5.0° N** |
| Gripsland area, Victoria | 38° S | 147° E | 8.0° N** |
| Cape Otway, Victoria | 39° S | 143° E | 5.9° N** |
| Tasmania | 42° S | 146° E | 5.3° N** |
| New Zealand, South Island | 45° S | 169° E | 16.3° N** |
| Antarctica | 65° S | 55° W | 18.7° S** |

TRIASSIC AND RHAETIC COALS

| Area | Present Location | | Triassic Lat.' |
|---|---|---|---|
| *North America* | | | |
| Mixteca district, Mexico | 23° N | 98° W | 41.7° N |
| Sonora, Mexico; approx. center | 30° N | 110° W | 52.8° N |
| Deep and Dan rivers, North Carolina, USA | 35° N | 78° W | 25.5° N* |
| *Europe* | | | |
| Bosnia, Yugoslavia | 42° N | 17° E | 28.4° S* |
| Dalmatia, Yugoslavia | 43° N | 17° E | 27.7° S* |

(Table 6—*Continued*)

TRIASSIC AND RHAETIC COALS

| Area | Present Location | | Triassic Lat.[1] |
|---|---|---|---|
| Udine, Italy | 46° N | 13° E | 23.7° S** |
| Austria, Northern and Central Alps | 47° N | 15° E | 23.4° S** |
| Vosges, France | 48° N | 7° E | 20.6° S** |
| Bernholm, Denmark | 55° N | 15° E | 15.7° S** |
| Oresund, Sweden | 56° N | 16° E | 15.9° S** |
| *Asia* | | | |
| Yunan Province, China | 25° N | 103° E | 7.8° S** |
| Kueichou, China | 26° N | 107° E | 4.1° S** |
| Hupei, China | 33° N | 112° E | 2.5° S** |
| Province of Bitchu, Japan | | | * or ** |
| Mount Demavend, Persia | 36° N | 52° E | 32.5° S |
| *Australia and New Zealand* | | | |
| Queensland, southwestern | 25° S | 150° E | 16.7° N** |
| New South Wales, northeastern | 31° S | 152° E | 15.1° N** |

* Deposits that lie just outside the Trias-Jura tropics.
** Deposits that lie within the Trias-Jura tropics.

The very definite location of these coal deposits within the Trias-Jura tropical and subtropical zones cannot be a mere coincidence. The distribution indicates that the lithosphere was shifted, as assumed, during Trias-Jura time, and that tropical and subtropical floras were the origin of these deposits.

The absence of any evidence indicating the presence of extensive ice sheets in the Northern Hemisphere during this period is as we should expect it, since, if the lithosphere was displaced as assumed, the North Pole would lie in the Pacific Ocean remote from land areas.

During the Permo-Carboniferous Ice Age, four areas were very severely glaciated—Australia, South America, India, and South Africa. The available evidence of abnormal climates, both warmer and colder, during this period seems definitely to support the assumption that the lithosphere was displaced during Permo-Carboniferous time, but space will not permit a lengthy discussion of it in this paper. It will suffice to mention a few facts:

1) The centers of the ice sheets of South Africa progressed in a west-east direction.

2) Although the Permo-Carboniferous coal deposits were widely distributed over the earth, 95 out of 105 of those listed in *Coal Resources of the World* lie within or just outside the tropics, as determined on the assumption that the North or South Pole lay under the center of one of the Permo-Carboniferous ice sheets. The remaining 10 are uncertain because I have not succeeded in locating them. Included among the 95 are the coal deposits of Antarctica and Siberia.

3) The Squantum tillite near Boston, Massachusetts (42° N, 71° W), is fully accounted for on the basis of this same assumption.

4) The more severe glaciation of the Southern than the Northern Hemisphere follows logically, since the North Pole lay under water the greater part of the time.

The assumption that the lithosphere was displaced during the Great Ice Ages seems adequately to account for the migration of species. Marine faunas and floras would naturally follow the changes in climate during the progress of an ice age, moving to and fro, from the Atlantic to the Pacific, through the north or south polar seas. Birds would fly over the north polar seas, and land faunas and floras would cross to and fro between Alaska and Siberia, over the land that bridged Bering Strait which, Wegener states, "lay above water in the Silurian and Devonian, again in Middle Carboniferous to Middle Permian, then Lias and Middle Jurassic (Doggar), and finally from Cretaceous to Quaternary."

At the end of each ice age they would naturally follow the climatic changes, and, when the lithosphere returned to its normal position, many similar species would be widely separated by great distances and impassable barriers. This offers an excellent opportunity for some very interesting research looking to the chronological correlation between the migration of species, the Great Ice Ages, and the bridging of Bering Strait.

From this brief survey, the assumption that the lithosphere was displaced during the Great Ice Ages seems to be supported by:

1) The localization of the ice sheets of North America and northwestern Europe.

2) The close agreement between the curves

showing the relationship between the terminal moraines of modern (Fig. 1) and Pleistocene (Fig. 2) mountain glaciers and their respective latitudes.

3) The warmer-than-normal climates that just preceded the glaciation of northwestern Europe, and of Alaska and Siberia during the greater part of Pleistocene time.

4) The confinement of the Trias-Jura coal deposits within the Trias-Jura tropics and subtropics, and the mild climates over the greater part of the land areas of the earth at this time.

5) The comparable distribution of the Permo-Carboniferous coal deposits.

6) The unbalance in the glaciations of the Northern and Southern Hemispheres during all three of these Great Ice Ages.

On the basis of these facts, I believe that we are fully justified in concluding that the lithosphere was displaced, as assumed, during the Great Ice Ages, and that the displacements were the direct cause of the alterations in climates during these periods.



## SMO ON THE AIR

| Station | Sponsor | Time |
|---|---|---|
| | **Sunday** | |
| KLBM, La Grande, Ore. | Baker-Union Department of Health (Research Report) | 10:15 A.M. |
| | **Monday** | |
| WOI-FM, Ames, Iowa | Iowa State College of Agriculture and Mechanic Arts (Articles of Interest) | 7:45 P.M. |
| | **Tuesday** | |
| WEVD, New York City | Wendell W. Rázim (Science for the People) | 9:00 P.M. |
| | **Wednesday** | |
| CKPC, Brantford, Ont. | The Telephone City Broadcast Limited (Modern Science) | 9:45 P.M. |
| | **(Irregular)** | |
| KBER, Baker, Ore. | Baker-Union Department of Health (Research Report) | .... |

**The Editor of THE SCIENTIFIC MONTHLY will be glad to cooperate with university or other educational stations interested in securing scientific material suitable for broadcasting.**

# A Century of Engineering Progress: 1852–1952

JAMES KIP FINCH

*J. K. Finch, long known to his colleagues as "Kip," is dean emeritus and Renwick professor emeritus of civil engineering at Columbia University. He has been at Columbia, his alma mater, since 1910 and has been dean of its far-famed School of Engineering since 1946. McGraw-Hill has recently published his book on the theme developed in his article—the tremendous influence that engineering has had on Western civilization.*

ANY attempt to summarize the advances that have taken place in engineering during the past hundred years leads inevitably to generalizations that demand qualification—to statements that immediately raise, in the mind of the reader, a host of reactions that begin, "Yes, but. . . ." Clearly, we are dealing with a century of ever-increasing complication and complexity. The older, largely independent, isolated, and self-sufficient rural life, which most of our people led a hundred years ago, has been in the process of replacement by nothing less than a completely new culture. No longer are we a nation of small, self-sustaining units. A family economy has been replaced by a highly interdependent national—in some respects international—exchange of goods, the majority of which were formerly produced at home. Man—or even the family—can no longer stand alone. We are dependent upon others for the bare necessities of life, not to mention new services we now regard as essential. The economy under which we live is no longer under individual control and one in which we may, with relative ease, visualize our needs and wants and adjust our resources to meet them. It is, in fact, so involved that even the economic doctors, although aware of many symptoms, dispute causes and differ widely as to cures.

Engineering and science are intimately interwoven in the complicated fabric of modern life, for they have, on the one hand, created this new culture and, on the other, the ever-changing economic and social demands of the day are primary incentives to continued and more rapid engineering and scientific development. One naturally expects, therefore, to encounter cross-currents and conflicting influences in a field that has played a dominating part in creating a new and complex way of life.

Engineering is no newcomer in the life of man. For fifty centuries, at least, engineering has been a potent instrumentality in the rise of Western civilization. What developments, then, in the scope and character of modern engineering account for the remarkable changes of the past century, in bringing about which engineering has been the prime force? Certainly one of these has been the part played by the engineer in the Industrial Revolution, for we are still struggling with economic, social, and political problems that arise from the mechanization of industry, and what a famous president of the American Society of Civil Engineers, George S. Morison, once called "the manufacture of power."

The main stream of engineering history may be followed back to at least 3000 B.C., in the fertile valleys of the Nile in Egypt and the Tigris-Euphrates in Mesopotamia. The accomplishments and experiences of those earlier days were brought together in ancient Greece and enriched with improved technical understanding and practices. Building on this foundation Rome, in her turn, spread all over the ancient world standards of urban life that were not to be equaled for a thousand years. The Middle Ages intervened, ages when man went to school to learn to be civilized again. After the brief fruition of this schooling in the Italian Renaissance, France took over the leadership of the Western world and held it almost up to the time of the French Revolution.

The rise of engineering and Western civilization had thus been concurrent, but the engineering of the great period of French leadership was still unchanged, was still, in essence, ancient engineering. It was still public-works engineering—roads and bridges, canals, harbors, and water supplies. The vast domain of industry and manufacturing remained almost untouched. French industries

were mainly rural, with those in the few urban centers dominated by the guilds, unprogressive and unchanging. Construction materials remained the timber, stone, and brick of ancient times—metals were too costly to use except for weapons, tools, and fastenings—and power was limited to the physical exertions of men and animals, plus the uncertain contributions of wind and water. But during the eighteenth century, the last great century of French leadership, the changes that were to form the basis for Britain's outstanding world position in the Victorian era, as well as for our life today, were in the making across the Channel.

Based on the development of the coal (i.e., coke) process in lieu of the charcoal which had almost denuded Britain of her forests, the British iron trade was revived by the Darbys. Wilkinson added to the cast-iron era which followed, and, by the close of the century, Cordt had developed his puddling process and rolls for wrought iron. A real Age of Metal was inaugurated. The first iron bridge in the world was built at Coalbrookdale in 1779. Kay, with his fly-shuttle of 1732, began the mechanization of the textile industry, which, carried forward by Cartwright, Arkwright, and others, has, until the past thirty years or so, been the dominating industry of industrialized nations. Then, about the time of our own American Revolution, Watt, first making economically practicable Newcomen's mine pump—in response to the growing demand for coal—went on to develop the rotative engine and, thereby, to start a new era. The development of industrial tools and machinery had been going on for centuries and was certain to continue. It was the advent of steam power to turn the wheels of industry that made it possible to replace hands by machines. The steamboat and the steam railroad followed in the early nineteenth century, providing another essential—adequate transportation for the exchange of goods.

When the American Society of Civil Engineers was founded in 1852, therefore, it was at a time when the United States was in the process of adopting and adapting these fruits of Britain's newly evolving way of life to our own needs and problems. Transportation facilities were the major requirement. Here each state of the Union sought, not primarily to strengthen union by intercommunication, but to secure the advantages of trade with the West. The Erie Canal of 1817–25 gave New York an outstanding advantage, but the Baltimore and Ohio railroad and the Pennsylvania canals and railroad also reached the Ohio. The westward movement was not to stop until the American people had spread across a continent, and the Pacific Coast had been linked by rail with the East. The Union and Central Pacific railroads met in 1869, but our greatest decade of railroad building—over 70,000 miles of track—came in 1880–90.

In other words, the nineteenth century in the United States was almost completely dominated by the transportation problem, and, after the early canal era and the Cumberland road venture of the federal government, it was the railroads that took the center of the stage. This is not to say that there were no other engineering or industrial developments. Our major cities—first Philadelphia, then New York, and then Boston—had their water supply problems. There was also some vitally important industrial pioneering. But in view of what was to take place after 1900—in the second half of these hundred years under review—America's industrial growth of the nineteenth century seems puny indeed—merely a making ready of the way.

The Philadelphia Centennial of 1876 forms a convenient reference date. The power needs of this exhibition were met by the giant engine designed by Corlis—a 1400-horsepower, low-speed, low-pressure, reciprocating engine far more perfect mechanically, of course, but differing in no basic




About 1620 Galileo undertook to analyze the overhanging beam and may be said to have established the idea of the external bending moment acting on the beam and the internal resisting forces, but he was led into erroneous assumptions. It was two centuries later before Navier gave us the common theory of flexure substantially as we have it today. (After Todhunter and Pearson, *History of Theory of Elasticity.*)



William John Macquorn Rankine: 1820–72. Famous professor of civil engineering at Glasgow, whose books, *Applied Mechanics* (1858) and *The Steam Engine* (1859) were the result of what A. N. Whitehead has called the wedding of natural science and engineering which took place about a century ago.

way from the Watt engine of a century earlier.

This was clearly a showpiece, which did not reflect American power needs. American manufacturing was still localized in the New England states and around New York City and Philadelphia. The numerous smaller industries of the East still relied on the small water powers around which New England towns and villages had grown. Lowell on the Merrimac and then Holyoke on the Connecticut offered larger water-power sites. The industries of the coastal cities required steam power, but the demand was for relatively small units, say, 25 horsepower or less—usually small, noncondensing, inefficient reciprocating engines. As a matter of fact, if one seeks for the best in steam power in the nineteenth century, he must turn to steamships. The largest stationary reciprocating engines ever built (7500 horsepower) went into the powerhouses for electrification of the Elevated Railroad and the first New York subway in 1902–04, whereas two engines each twice this size on a single shaft had driven the screws of the *Campania* and the *Oceanic* in 1893 and 1899.

It was not until the eighties that the Indians were finally subdued and we realized that our geographic frontiers had been reached and we could turn around and take stock of our winnings. It is true that Eli Whitney, of cotton gin fame, had adopted interchangeable manufacture in the making of muskets in 1792, that we had stolen textile machines from Britain in spite of her best efforts to prevent their export, and that, by the time of her great London exhibition of 1851, "the American system" of manufacture had created a great stir abroad. But the real American Industrial Revolution was yet to come. Our earlier advances had been primarily those of territorial conquest. Those of the twentieth century were to be based on the technological and industrial exploitation of our resources.

There is hardly a single curve of engineering or industrial growth which does not turn sharply upward after 1900. Possible exceptions are railroad building (we reached our maximum railroad mileage—253,000 miles, enough to encircle the world ten times—in 1920) and coal mining which, after a World War I peak, declined with the advent of by-product coke ovens and oil competition. Our first billion-dollar corporation, U. S. Steel, came in 1901. The American Portland cement industry was born at the beginning of the century. Brick and stone gave way to mass-produced concrete. The development of the automobile not only created a major industry but ushered in the Highway Era, with demands for highways and superhighways we have yet fully to meet, and, happily for the bridge engineer whose railroad employment had run out, a period of great bridges that surpass in span anything the world has ever known. Steel began to replace wrought iron immediately after the Philadelphia Centennial, and by 1950 we were turning out over 1000 pounds for every man, woman, and child in the country as compared with possibly 15 or 20 pounds of iron a century ago. Copper also was on the way up, but by 1946 aluminum had become less costly per pound than the red metal.

World War I marked in many respects a climactic date in American engineering, as we shall note. It also marked the rise—or at least a remarkable expansion—in the American chemical industry. Discovering that we had been dependent upon Germany for many of our chemical needs, older companies, such as Du Pont, began to broaden their fields of interest, and new industries were built on the German patents confiscated during the war

years. The astounding growth of the American chemical industry followed.

But in no field of human endeavor has the American Industrial Revolution been more marked than in that of the generation and utilization of power. It has been reliably estimated that in 1900 there was available in the United States power equipment totaling about 25 million horsepower, or about two man power per capita. In other words, earlier centuries had produced two silent slaves to relieve man of physical toil. The past fifty years have seen more than a fifty-fold per capita increase.

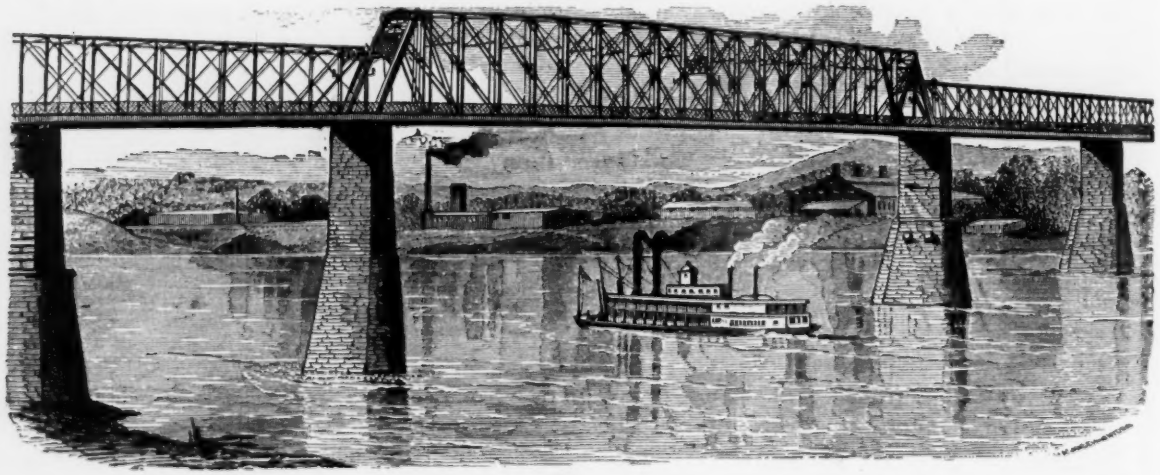
The power manufactured by, and purchased for, industry in 1900 was about two horsepower per industrial worker. It is now in the neighborhood of ten horsepower. Recalling that it takes from six to ten men to equal a horsepower, this means that the physical power of our modern industrial worker has in the past century been multiplied a hundred-fold. Every man, woman, and child in the world could not provide the power to turn the wheels of American industry alone.*

* The writer was lecturing recently to a group of college students in a hall lighted by 16 electric bulbs of 75 watts each. He remarked that it thus required 1.2 kilowatts, or electric horsepower, to keep these lights going. Since a kilowatt is about 1 1/3 horsepower, this is equivalent to 1.6 horsepower. Suppose horse-treadmills were used to drive dynamos to supply this service. At best they would not be over 50 per cent efficient, and it would thus take three plodding horses to keep the lights lit; or, even more telling, probably close to 30 treadmill men. Yet one can hold in his cupped hands two pounds of coal which, costing but a few cents, are transformed by the miracle of power into the current which will maintain these lights for an hour, and so on, hour after hour, without rest or relaxation.

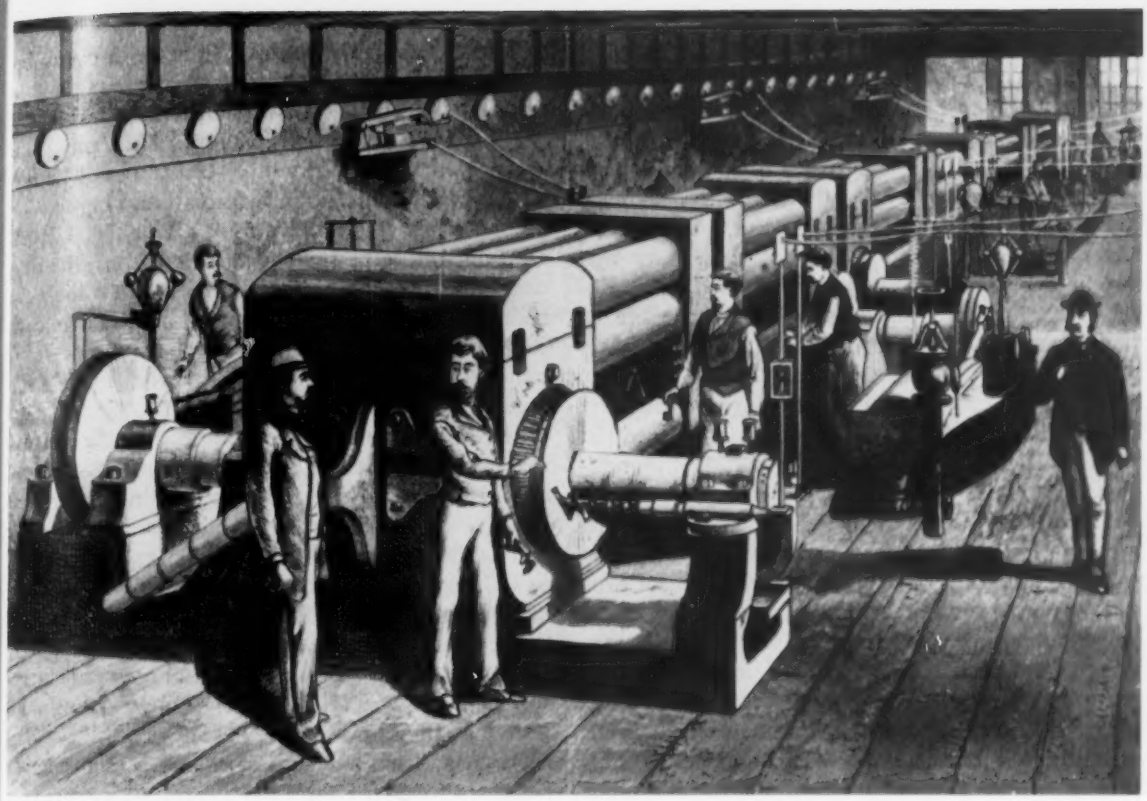
It should be noted also that a large part of modern power equipment is in portable gas engine form. The number of motor vehicles in the United States today is some 50 million, or the equivalent of one for every three inhabitants, and there are in addition the millions of gasoline- or oil-powered farm, construction, and other machines.

Back of this tremendous expansion, there have of course been many stimulating forces: a widespread demand sustained by a widespread purchasing power; the remarkable increases in the wages of labor since 1900, which have forced the substitution of machines and power for men; and, certainly a basic influence, the development of electrical means of transmitting and utilizing power. Electric lighting may claim perhaps 10 or 15 per cent of power service but, whereas only 4 per cent of our tools and machines were electrically operated in 1900, over 75 per cent were so individually driven in 1927, and one seldom sees another type of machine today.

And what has this all meant to the American people? On the material side, American production has been increased five- to sixfold in the last half-century. In these same years our population has about doubled, so that this means that each of us has today two and one-half to three times the goods and services that were available fifty years ago. But this is not all. Mass production demands mass consumption. We have had to find, and still have to find, useful, productive employment for some 600,000 new workers every year in order that they may have the purchasing power to enjoy this increased production. We hear much of the mo-



Early, long-span American truss bridge, 1876. This 515-foot pin-connected truss over the Ohio on the Cincinnati Southern Railroad, designed by J. H. Linville, was a pioneer long-span work. It also reflects the development of typical American forms of bridge construction and the use of modern standards of design as set forth by L. G. F. Bouscaren's specifications, including stresses computed for concentrated, moving locomotive loads. (After Comolli.)



Edison's Pearl Street Station, 1882. The huge, long-pole dynamos were set horizontally and driven by piston engines at the left-hand side. The dynamo was later improved magnetically and made more compact and efficient. It is estimated that 30–40 pounds of coal per kilowatt hour produced were required at this first electric power station. (Courtesy Edison Institute.)

notony of modern industrial life, of the loss of the pride and incentive, the creative satisfactions, of our earlier craftsmanship era. The answer is, of course, that a craftsmanship era could not maintain our standards of living of the present day. And how many of us have any gifts of craftsmanship? We forget also that in earlier days "man's work was from sun to sun and woman's work was never done." Those were the days when the majority of men were "brothers to the ox." Since the turn of the century American technology and industry have created useful, productive employment for millions who possess no unusual gifts yet who can, thanks to modern machines and power, and in a forty-hour week, afford standards of living never before paralleled in human history.

Engineering has been, indeed, the great leveling force in the history of man. It has done much to compensate for the differences of night and day, of heat and cold. Through transportation and power it has made possible the equalization of differences of location. The farmer, as well as the city dweller, can enjoy the comforts and conveniences of the Power Age. Industry, with its higher standards of living, has spread from New England over all the states, until today there is not a state in the Union that produces less than $25,000,000 annually of manufactured products and only four that produce less than $100,000,000. And the end is not yet. We are apt to forget that this modern age has also done much to man's productive abilities. Millions who operate machines do not possess the natural gifts essential to manual production. Indeed, the great danger of this era of equal opportunity which modern technology has brought about is that, in our search for equality, we may easily fall into the error of failing to recognize the importance of quality—of the special gifts from which these advances spring.

Yes, it is a complex and complicated life we lead and it has raised many new economic, social, and political problems. At times it seems that man has, in this past century, come in the grip of a new evolutionary force—a dominating power which urges him ever onward to new developments, new problems, and new adjustments, but one from which he cannot sever his connection and from the continued and ever-more rapid evolution of which he cannot restrain his efforts.

Certainly one of the most important factors in

increasing the scope and tempo of this movement over the past century has been the liaison between the natural sciences and engineering. Although the general pattern of modern engineering development was well established in 1852, the past hundred years have witnessed a long-delayed *rapprochement* between the two activities. As A. North Whitehead has remarked, it was just about a century ago that a developed science wedded itself to a developed technology and a new era in the life of man began. This story fits perfectly into the brackets of time we have been reviewing. Has this wedding, then, been the determining factor in creating the new epoch? What part has science played in modern engineering progress? What is the relationship of science to engineering?

Today's engineering is, of course, but the modern version of several ancient practical arts: the art of construction, the mechanical and chemical arts, and the arts of mining and metallurgy. One is immediately impressed with the fact that the majority of the areas of engineering interest and the methods or means used in engineering practice are thus of very early origin. Engineers built roads and bridges, harbors, aqueducts, and water supplies, developed steam power, the steamboat and railroad, extended the scope of engineering activities into our industrial life, all before, and sometimes centuries before, there was any relationship between natural science and engineering. Why, then, should there be any liaison between these two interests now?

There is, of course, a fundamental difference of purpose between natural science and engineering. Science seeks to explain, to explore causes, and to increase our understanding of nature. Engineering is, on the other hand, creative, seeking to satisfy man's material needs and wants within the economic framework of the times. Their common interest derives from the fact that the engineer, in shaping our environment and exploiting our resources for the better use and convenience of man, is inevitably working with or against natural forces or making use of nature's gifts. What we may not always remember, however, is that this dual interest in a common area is not the full story. It has been said that the pure science of today becomes the applied science of tomorrow. There may possibly be some exceptions, and it is undoubtedly true that, through modern organized developmental research, we are shortening the gap between scientific discovery and its application and use in engineering and industry; but if history teaches us anything it it that the quick transformation of discovery to use is simply a bit of wishful thinking.

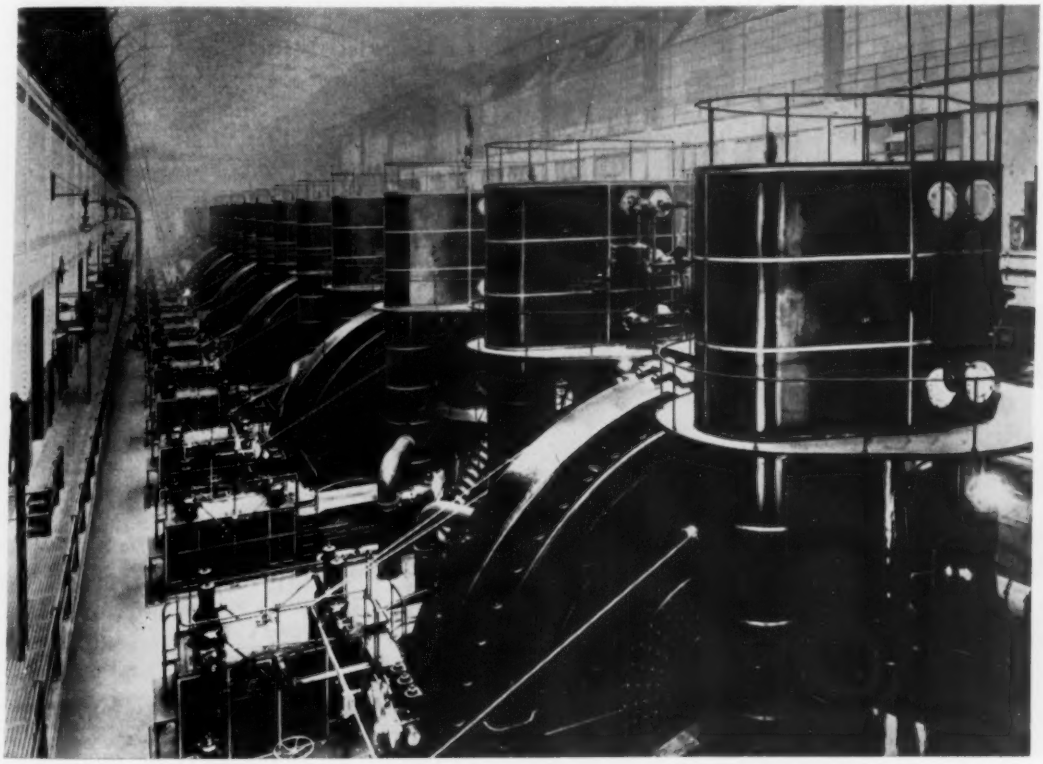
There is a clearly defined sequence of events between scientific discovery, on the one hand, and its practical, creative use, on the other. Several factors are involved in the process. In the first place, the engineer has never been able to wait until he had all pertinent information before attempting to meet the material needs and wants of his day. The doctor does not refuse to treat a patient because he does not fully understand the disease from which the afflicted one suffers. Engineers built stone arch bridges for at least two thousand years before they had more than a shrewd idea of what made them stand up. Even today, although an empirical, rule-of-thumb design based on these centuries of experience is quite simple and easy, a rigid, scientific, quantitative analysis of the stresses in this ancient structural form is almost impossible.

The steam engine, the steamboat, the railroad, as well as the truss bridge, the suspension, and the arch, were all well developed before the science behind them was known in more than the purely intuitive, empirical, qualitative manner which resulted from years of training, observation, and practice. In short, we had bridges before we had even an approximate bridge theory, steam engines before the modern theory of heat, and, in our own day, the science of aerodynamics has followed the invention of the Wright brothers.

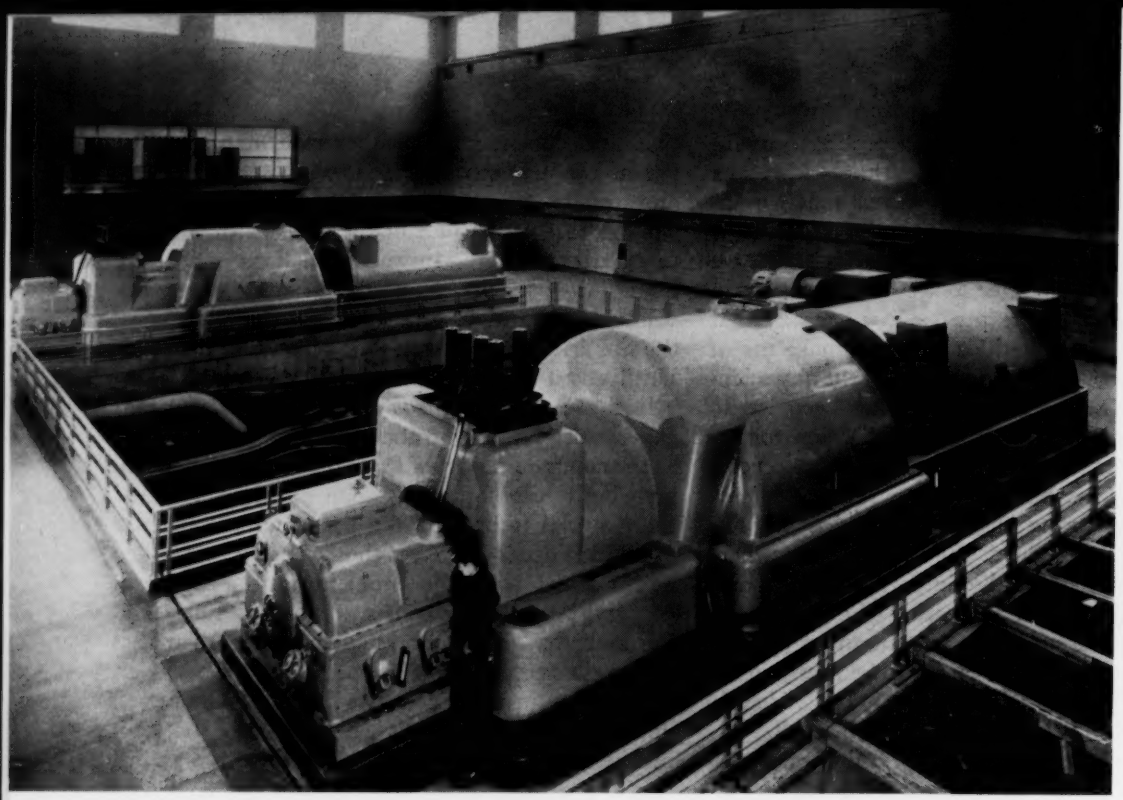
The first step in the birth of a new engineering product is invention—the marriage of an idea with the means of its realization. And, contrary to popular belief, the role of science in this process has usually been secondary. Natural science is, after all, a quite modern growth. For centuries, as a result of the narrowness of Greek thought and, later, the dominance of the church, the growth of science was impossible. It was not until the sixteenth century that science was made free, and not until well into the nineteenth that the term "natural philosophy" passed out of use. The eighteenth century marked a notable advance, but in the earlier ages such science as existed offered little or nothing to the engineer. Watt made it clear that he owed nothing in his steam engine invention to his friend Dr. Black's discoveries—nothing to more than a quite obvious common sense, experience, and observation. Bell's invention of the telephone was, of course, made possible by the use of the electromagnet, but the idea of transmission of speech was pure Bell—it did not originate with the magnet. The Wrights learned to fly through actual trial and error rather than as the result of any scientific discovery. It has been argued that Faraday was the real inventor of the dynamo. He unquestionably discovered magnetic induction, but it took at least

fifty men fifty years to produce a practical, useful dynamo. It is undoubtedly true that within the past century scientific knowledge has made it increasingly possible to realize inventive ideas. It is also true that within the past fifty years or less we have passed into another phase in invention in which, occasionally, the process is reversed; that is, we seek an inventive idea that will make use of a scientific discovery. But to assume that any scientific discovery will, as the public has been led to believe, find practical use and application tomorrow is sheer nonsense. Actually, new and revolutionary inventions have played a far less important role in creating the age in which we live than is generally assumed. We must look elsewhere for the major and vitally important role which science has played in increasing the scope and power of engineering in the past hundred years of their married life. The answer is to be found in the improved technique which science has aided in developing within the engineering field itself.

Before the middle of the last century the technique of engineering design was based almost entirely on an intuitive sense or feeling for design, ripened and developed by experience. It was empirical design, largely rule of thumb, purely qualitative, and dependent on rather rare, natural gifts. Beginning in France in the late eighteenth century, and greatly strengthened and extended by British workers in the first half of the nineteenth century, more rigid, more fully rationalized scientific, quantitative techniques of design were slowly developed. The history of a single structural element, the simple beam, illustrates the difficulties involved. Until about 1830–40, the size of a beam to carry a load over a span was a matter of judgment and experience. We did not have what is known today as the common theory of flexure by means of which, knowing the load and the span and having tested the material to be used, we may compute the size of a beam needed to meet these conditions. Galileo had worked with the problem in the sixteenth century, but on erroneous assumptions. Euler and Bernoulli had been interested in the mathematics of the elastic curve of a beam. About 1820 Navier, a professor in the Ecole des Ponts et Chaussées, developed the basic theory in practically the form in which we have it today. But it took such practical workers as the British engineers Tredgold and Barlow to test beams, discard the unnecessary mathematical complications of the earlier "elasticians," and produce a workable technique of design.



The New York Subway Powerhouse, 1904. The largest stationary reciprocating engines ever built, 7500 horsepower each, these were low-pressure (175 lbs.) compound engines (cylinders 42 and 86 in.) of long stroke (60 in.) and low speed (75 rpm).



A modern turbine room, 1949. Showing two 65,000 horsepower 21-stage turbogenerators, each of which, operating at 3600 rpm, is equivalent in output to almost nine of the New York Subway units and far more efficient.

That is, progress in engineering science, although based on the understandings of natural science, is developed and made useful and applicable not by scientists but by engineers.

This search for more fully rationalized, more accurate, quantitative techniques of design to replace the older empirical, qualitative, and thus uncertain judgment techniques of the past still goes forward today of course—at an ever-increasing tempo. World War I may be said, however, to have marked a turning point in the general character of this search. The nineteenth century was marked by what may be called the "coefficient method of attack." Engineering science was a curious combination of a few basic scientific formulas modified by experimentally determined coefficients which allowed for the many, still unknown factors that were always encountered in practice. A notable example was hydraulics, in which the flow through an orifice, to take a simple case, was based on the Torricelli theorem: $q = av = a\sqrt{2gh}$; but a coefficient, varying with the shape and size of an opening and determined by experiment, was introduced to reconcile theory with practice. Large-scale experimentation was the order of the day. With the turn of the century we began to analyze the behavior of the coefficients, what had been called the factors of ignorance. Viscosity, inertia, basic parameters such as the Reynold's number, not only led to new understanding, but to the ideas of dimensional and dynamic similarity that made it possible to relate model tests to prototypes. Fluid dynamics was born. Large-scale experimentation was, in many cases, no longer necessary.

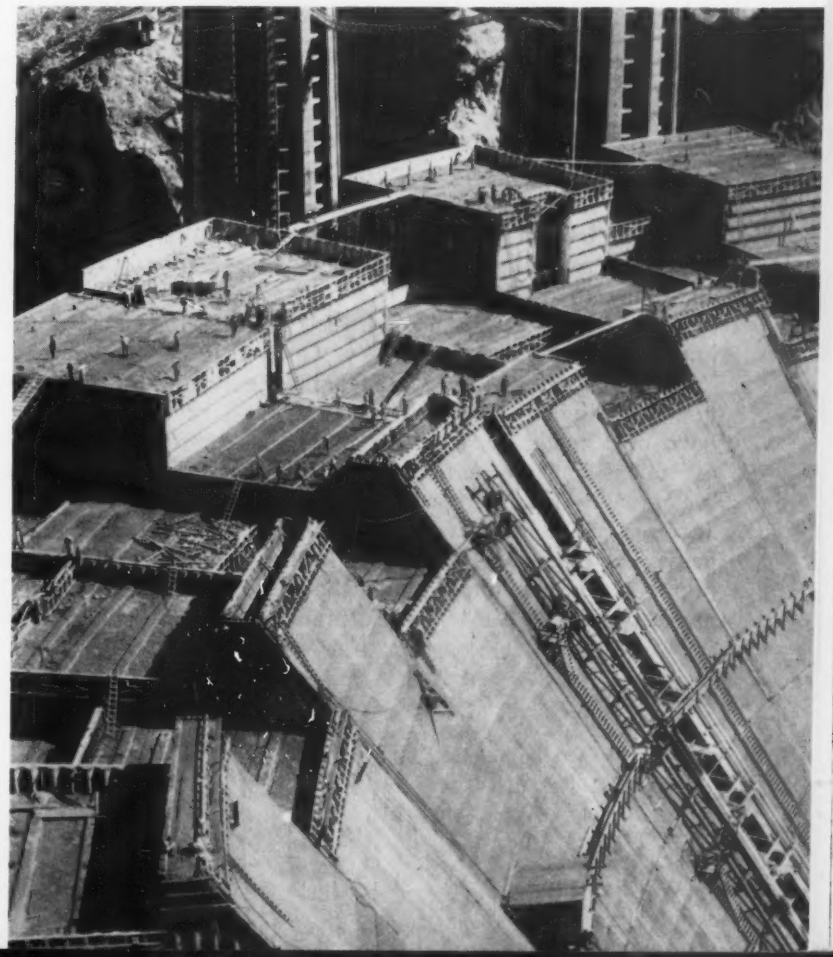
There is probably nothing so exasperating to the natural scientist as the time-lag between theory and practice. He is apt to regard the engineer as a slowpoke if not actually an incompetent. There are two obvious answers to this criticism. In the first place, the scientist naturally has his own interests, and they are seldom those that furnish direct grist for the engineer's mill. As in the case of the medical profession, the engineer has had to dig out the great bulk of his practical science himself. Of the group of subjects which have long been known as engineering science, this has been true especially of thermodynamics, hydrodynamics, and the mechanics of materials and structures. Furthermore, the problems involved in such digging are often complicated. Take, for example, one of the most recent areas of engineering interest to succumb, at least in part, to rational, scientific analysis, namely, soil mechanics. There are at least a dozen complex, interrelated variables involved in the physical behavior of any one soil. In addition, there are few conditions in nature where any such thing as uniform soil conditions occur. Physics, of course, aids us in explaining such basic phenomena as

cohesion, capillarity, grain shape and size, but these are only elements in a complex problem; and the engineer wants more than explanations, he wants to know in advance how much a bridge pier will settle, or what is the stable slope for an earth embankment. These are clearly not problems in which the scientist would be interested.

There is also another fundamental fact that is too often ignored. The main service of natural science to engineering has been in the development of a more fully rationalized, scientific, quantitative technique of design, but design is not an end in itself; it is merely a means to more effective and efficient production or construction. The most highly scientific and accurately designed device or product man can conceive has no merit unless it offers better service at less cost than some existing device or product. It is because more scientific design offers possibilities of such economy that the search for further rationalization of engineering design never ends. It would be almost impossible to mention a single engineering device, product, or method which has not been improved through specialized scientific study and analysis. But there are external factors that strongly influence this trend and that demand attention. They can best be exemplified by the rather wide differences between American and European engineering development.

In the first place, one of the major advantages of scientific design is that it results in a saving of materials. Overdesign is avoided, and parts of a structure or machine are made no larger than is necessary to meet the loads coming upon them. Similarly, the scientifically designed steam engine uses less coal, the improved electric light fewer watts per lumen. But, in many cases, such exact and materially economical design involves more labor, and more highly skilled labor, to produce.

As early as 1838 a British engineer visiting the United States remarked that American design differed from European practice primarily because, although we had an abundance of materials, skilled labor was scarce and costly. Throughout the nineteenth century the basic desiderata in engineering design were ease and speed of production. We did not hesitate to use a few more pounds of steel or a yard or two of concrete if this would result in a saving of labor or reduce the period during which capital would be idle and unproductive. These ideas have influenced all our engineering activities, from the development of labor-saving machinery to the design of bridges that could be largely shop-made and in which field operations were reduced



The Boulder Canyon Dam, 1936. Design is but means to intelligent, effective, and economical struction. The greatest advances made in erican engineering have been primarily in pro- tion and construction methods. This huge struc- , 730 feet high and involving 3 million cubic of concrete, was built in five years, 1931–36.

to a minimum. We have been the greatest labor savers and producers the world has ever known, but until recent years, we have paid little attention to "unnecessary refinements" in design.

In Europe, on the other hand, skilled labor has been relatively plentiful and materials relatively costly. As a result, European engineers have sought the utmost in the refinement of design. In 1851 an American, Squire Whipple, published the first text dealing with the analysis of truss bridges, but with few exceptions we have contributed little to the development of engineering science since. We have left this to European workers and not infrequently have regarded them as "mathematical geniuses without a practical hair on their heads."

This situation began to change about the time of World War I. To what extent it was influenced by a change in the relative cost of materials and labor and the increasing cost of supplies is problematical. In the structural field the demand for larger structures, in which economy demanded more exact analysis, and secondary stresses could no longer be ignored or provided for by generous overdesign, played a part. The development of the airplane, a flying structure of intricate design, was another factor. The replacement of direct current by a far more complex alternating service posed new problems. The coming of the steam turbine, and the growth of demand to the point where Corlis' giant steam engine of 1876 of 1400 horsepower became a joke as compared with modern turboelectric units of 280,000 horsepower, stimulated a far more exact study of thermodynamic and similar problems. Edison's famous Pearl Street Station in New York of 1882 probably used 30 or 40 pounds of coal per kilowatt hour produced. By 1900 this had been reduced to 7 in the better plants and today it is 1 or less—an over-all heat efficiency of about 30 per cent. And there is still room for improvement.

Where have we secured the basic theory and understanding by which these more recent advances have been made possible? There are, of course, exceptions, but in general we have imported them, ready-made, from Europe, mainly from Germany. It seems safe to say that American engineering has gained far more in power and refinement of techniques from such importations than it has from any American advances in natural science. We have been backward in the development of engineering science in this country, and our contributions in some fields of natural science have correspondingly not been outstanding.

It is of course true that scientific knowledge has generally been made quickly and readily available to the entire world and it is, thus, as Ewart Smith has observed, on the technical and industrial use of knowledge, on industrial practice and know-how, on the state of engineering science, that the industrial and economic position of a nation depends. It has been frequently noted that World War II made it impossible for us to rely any longer on European sources for either the research that leads to scientific discoveries or the basic studies that result in improved engineering science and practice. Furthermore, Russia has "imported" extremely able German talent and is not revealing the results of their labors to the world. The fate of the world rests today, as never before, on scientific and technological leadership. And this, in turn, is primarily a problem of our understanding the relationships of science and engineering. We have a tremendous backlog of scientific knowledge on which to draw for improved engineering practice, but we must be the first to discover new scientific knowledge. We must also be the first to learn how to use and apply such knowledge in improving and advancing our engineering and industrial knowledge. One activity that grew and developed greatly during the depression years and that has been further stimulated by World War II is research. We must see that in this development we do not overemphasize either research in natural science at the expense of research in engineering science or vice versa.

Unlike Russia, we are aiding the backward nations of the world financially and with technical advice and direction in attaining the same standards of life that the American Industrial Revolution has brought to us. But we would be blind indeed if we failed to realize that not only the dislocations of World War II but also this widespread gift of technological and industrial know-how pose a challenge to American science and engineering that must be met in the years that are to come. The challenge of the past Century of Progress in Engineering, great as it has been, is completely overshadowed by the challenge we face today.



# Aimlessness in Education

ARTHUR E. BESTOR, JR.

*Dr. Bestor (Ph.D., Yale, 1938) speaks, in the article below, from long experience. Beginning at Yale as an instructor in history in 1931, he has taught and lectured widely ever since. He was at Columbia and Teachers College in 1936, at Stanford from 1942 to 1946, a Newberry fellow at Chicago's famous Newberry Library in 1946, and at the University of Wisconsin in 1947. He has been in the Department of History of the University of Illinois since then. He was made a member of the Committee on American Civilization of the American Council of Learned Societies in 1950.*

"IF A nation expects to be ignorant and free," said Jefferson, ". . . it expects what never was and never will be." Americans have taken this dictum to heart. No belief is more firmly held in the United States than belief in education. But belief is not enough. We must understand education as well as believe in it. The thing that counts, after all, is not the number of schoolrooms we have, but what goes on in them. And if we really believe that education is vital to our safety, then we need to know exactly what kind of schooling constitutes genuine education, and what kind is merely a gaudy show.

Education, first of all, is the opposite of ignorance. Jefferson makes this clear. The phrases he uses elsewhere as synonyms of education indicate the positive meaning he attaches to the concept. The kind of schooling that is vital to a democratic society is the kind that results in the "spread of information" and the "diffusion of knowledge;" the kind that regards "science . . . [as] more important in a republican than in any other government;" the kind that recognizes that "the general mind must be strengthened by education;" the kind that aims to make the people "enlightened" and to "inform their discretion."[1] These are the ends that the schools must serve if a free people are to remain free. These, be it noted, are intellectual ends. Genuine education, in short, is intellectual training.

The nation depends upon its schools and colleges to furnish this intellectual training to its citizenry as a whole. Society has no other institution upon which it can rely in the matter. If schools and colleges do not emphasize rigorous intellectual training, there will be none. This is not true of the other services that educational institutions may incidentally render. It is well for the schools to pay attention to public health, for example, but if they are unable to do so, the health of our citizens will not go uncared for. The medical profession and the existing welfare agencies remain unimpaired. But if the schools neglect their central purpose of intellectual training, the loss to society is an irreparable one.

The loss is catastrophic whether or not the students concerned go on into college; in point of fact, the situation is more dangerously irreparable if they do not. College preparation, in other words, is not the matter at issue. A command of written English, mathematics, science, history, and the other disciplines in which we find high school graduates so often deficient, is vital for many things besides advanced study. Throughout history these intellectual disciplines have been rightly considered fundamental to education for practical life and for citizenship. Every vocation has grown more complicated in the modern world. The artisan of an earlier century might make his way in the world even though he were illiterate and all but unlearned in elementary arithmetic. Today even the simplest trades require more than this. The responsibilities of citizenship, too, are more complex than ever before. Intelligent citizenship does not mean merely a simple faith in American democracy. It calls for a thorough knowledge of political principles and institutions, of history, and of economics. It demands a clear understanding of the various sciences, for the intelligent citizen must help decide public policy on such complex matters as atomic energy. Above all, intelligent citizenship requires an ability to read, to understand, and to test the logic of arguments far more complicated than any that have hitherto been addressed to the public at large.

The economic and political life of a democratic state depends upon how successfully its educational system keeps pace with the increasingly heavy intellectual demands of modern life. Our civilization requires of every man and woman a variety of complex skills which rest upon the power to read, write, and calculate, and upon sound knowledge of

science, history, economics, and other fundamental disciplines.

The concept of education that I have just stated is *not* guiding the American public schools today. It is a concept which professors of education have repudiated, and which they caricature at every opportunity. According to a recent article by a professor of education, the scientists and scholars on university faculties

> . . . visualize the mind as a sort of cold storage warehouse, which is empty at birth. The process of learning consists in hanging on the walls of the warehouse chunks of fact and information. . . . The chunks hang there in the same condition in which they were first stored until some day the student needs one or more of them; then he can go into the warehouse, unhook the right chunk, and use it for some mature purpose which he could not have conceived in the immature condition of his mind when he first acquired the material. . . . The conception that new learnings become part of the learner through their digestion and assimilation into other previously acquired material is quite foreign to this idea of learning.[2]

I assume that incompetents can be found who perform thus. I doubt if anyone can be found who believes thus, and I am certain that I have never met anyone who would defend, nor read a single sentence that seriously propounded, such a doctrine.

The caricature in itself is unimportant. What is important is the fact that American educators are deliberately and consciously cutting the public schools loose from the disciplines of science and scholarship, because they think that what they are repudiating is the theory described in this quotation. Unfortunately, what they are casting away is something utterly different from this. The liberal disciplines are not chunks of frozen fact. They are not facts at all. They are the powerful tools and engines by which a man discovers and handles facts. Without the scientific and scholarly disciplines he is helpless in the presence of facts. With them he can command facts and make them serve his varied purposes. With them he can even transcend facts and deal as a rational man with the great questions of purpose and meaning.

Consider how the disciplines of science and learning came into being. The world is first known to us—and was to mankind—as a great tangle of confused perceptions. Before man can deal with it at all, he must differentiate one experience from another and he must discover relationships among them: similarity and diversity, cause and effect, and the like. Gradually he discovers that one kind of relationship can best be investigated in one way (by controlled experiment, it may be), and another in another way (by the critical study of written records or of fossil remains, perhaps). Thus th separate disciplines were born, not out of arbitrary invention but out of evolving experience. Trial and error, prolonged over centuries, has resulted in the perfecting of these tools of investigation. The methods can be systematized and taught, hence the intellectual power that mankind has accumulated throughout its entire history can be passed on to successive generations. Thereby each generation is enabled to master the new environment and the new conditions of life that surround it. This ability to solve new problems by using the accumulated intellectual power of the race is mankind's most precious possession. To transmit this power of disciplined thinking is the primary and inescapable responsibility of an educational system.

That present-day professional educators are seeking to evade this primary responsibility is the grave charge which members of the learned professions are making. The evidence is to be found in the educators' own widely publicized statements of educational aim. One carefully analyzed example is better than a score of quotations at random. Let us therefore look carefully at the curricular revision that is going on in the high schools of Illinois, remembering that similar movements are afoot in practically every one of the forty-eight states.

The Illinois Secondary School Curriculum Program is sponsored by the state superintendent of public instruction and has as its director the associate dean of the College of Education of the University of Illinois. Over the past five years it has conducted a series of studies, one of which—a so-called Follow-Up Study—will concern us here. This study makes use of a group of widely circulated questionnaires, all based upon a central document entitled *Problems of High School Youth*, prepared by a professor of education. Fifty-five problems are listed,[3] and the questions are essentially rephrasings of these items. The answers, it is said, will "afford a measure, at the level of informed opinion, of the performance of the school." And these, in turn, "will be helpful in 'engineering' an improved, broadly based consensus regarding what the local high school should be doing for its students."[4]

The first thing that strikes one on reading the list is the grotesque disproportion between the different problems presented. Trivia are elaborated beyond all reason, and substantial matters are lumped together in a very small number of separate items, thus reducing them to relative insignificance in the whole. Among the fifty-five points are these: "the problem of improving one's personal appearance," "the problem of selecting a

'family dentist' and acquiring the habit of visiting him systematically," "the problem of developing one or more 'making things,' 'making it go,' or 'tinkering' hobbies," and "the problem of developing and maintaining wholesome boy-girl relationships." Not a whit more weight or emphasis is placed upon the following, each of which constitutes but a single point among the fifty-five: "the problem of acquiring the ability to distinguish right from wrong and to guide one's actions accordingly," "the problem of acquiring the ability to study and help solve economic, social, and political problems," and "the problem of making one's self a well-informed and sensitive 'citizen of the world.' "

Needless to say, the scholarly and scientific disciplines have no place among these "real-life problems." Arithmetic has sometimes been considered of practical importance, but, although "athletic games," "camping," "collecting art objects, etc.," and "doing parlor stunts" are mentioned by name, each in a separate item of the list of fifty-five, not one of the branches of mathematics is even hinted at. The word "science" occurs nowhere in the list, nor any term synonymous with it or descriptive of its various branches. That history and foreign languages are absent, even by remotest implication, goes without saying. The final item on the list is "the problem of securing adequate preparation for successful college work. . . ." One can imagine that this will prove the most difficult problem of all.

The intermingling of the trivial and the important in these lists and questionnaires is not an accident but a symptom. It is not enough to say that "neither the order in which needs are given nor the amount of space devoted to each need is indicative of the relative significance of the different needs."[5] The arrangement of items in a list like this, and the attention devoted to each, do have a meaning—a very profound meaning. The order and emphasis of a man's writing are just as truly a part of what he says to his reader as any of his particular assertions. And what the list of *Problems of High School Youth* says to the reader is that order, balance, discrimination, and a sense of values are matters of no consequence whatever to the pedagogues who are remaking the curricula of our public schools.

Men who cannot compile a simple list without revealing their mental limitations do not inspire confidence that they will know how to accomplish even the saner of their objectives. Take, for example, "the problem of acquiring the ability to study and help solve economic, social, and political problems." The question for the educator is not *whether* the school should do anything in the matter, but *how*. The traditional curriculum offered a clear-cut answer: through careful and systematic study of history, political science, philosophy, economics, sociology, and the other relevant disciplines. The aim was to cultivate sound judgment based upon critical thinking and thorough knowledge. To the new pedagogical medicine man, however, all this is sheer pedantry, just as bacteriology is so much learned nonsense to the happy faith healer.

Political, economic, and social problems that have taxed the intelligence of the best-educated men from antiquity to the present are to be solved, so the educator blithely assures us, through a "common learnings course" in the high school, wherein "materials from science, literature, history, mathematics, industrial education, homemaking, business education, art, music, and all other areas of the curriculum would be included."[6] And from the *Problems of High School Youth* we are acquainted with the exquisite sense of order and proportion that a professional educator brings to the task of organizing a set of problems rationally and effectively. We must not detain him to ask for proof that his short cut to wisdom will actually produce it. After all, he has fifty-four other problems to wrestle with, and he must hasten on to the next—"the problem of acquiring the ability to select and enjoy good motion pictures," perhaps, or "the problem of acquiring the social skills of dancing, playing party games, doing parlor stunts, etc."

If men and women prefer the latter things to intellectual training, the educator will argue, should they not have them? The question is really irrelevant, for the questionnaires do not provide, and cannot provide, one iota of evidence that the public is making any such choice. The most damning part of the whole study is that the questionnaires it uses are patently dishonest. They purport to ask parents, citizens, teachers, and pupils what they "think is the job of the secondary school."[7] But the persons questioned are not permitted to give the slightest indication that they believe the job of the secondary school is to give intellectual training. In the entire battery of questionnaires there is not a single blank that one can check in order to express the view that the public schools should offer sound training in mathematics, in natural science, in grammar and composition, in foreign languages, or in history. The citizen may respond in the negative to every question implying the substitution of frivolous aims, but he cannot indicate in any manner whatever the kind of positive program he would favor. The questionnaires are so

rigged that the results are predetermined from the beginning. However overwhelming the public sentiment in favor of disciplined intellectual training may be, the professor of education who constructed the questionnaires has taken care that this sentiment shall not appear anywhere in the answers.

The Follow-Up Study is not an attempt to ascertain public opinion; it is a cynical effort to manipulate public opinion. It is obviously designed to manufacture the appearance of public support for curricular changes that the professional educators have determined upon in advance. This purpose comes out stark and clear in the official statements explaining the questionnaires: "Given the American tradition of the local lay-control of public education, it is both necessary and desirable that a community (patrons, pupils, teachers) consensus be engineered in understanding support of the necessary changes before they are made."[8] I find difficulty in following some of the involved syntax of this sentence, but I have no difficulty whatever in grasping the significance of a "consensus" that is to be "engineered." We approach here the real meaning of what educators euphemistically describe as "democracy in education." It is the democracy of the "engineered" consensus.

The lighthearted prospectus of these curriculum engineers contains this exhortation: "There are many ways of getting under way in a program of curriculum revision. The important thing is that we need to pry ourselves loose from the present situation. Maybe one lever will do the prying loose; perhaps, it may require several. . . . Pick your lever(s) and let's get started."[9] (The metaphor is apt. The kind of lever that one uses for prying things loose is sold in hardware stores under the name of wrecking-bar.)

Pry loose from what? The answer is implicit in the entire program. The secondary school curriculum must be pried loose from the established disciplines of science and scholarship. The public school must be pried loose from its relationship to institutions of higher learning. College entrance requirements are a thorn in the side of the public school directorate, for they give some support, feeble though it may be, to intellectual training in the secondary schools. The Illinois Curriculum Program is ready to deal with this menace to "real-life" education. It recommends "that the colleges adopt admission policies which do not specify the courses the students are to take in high school." College entrance requirements in the basic intellectual disciplines of "English, foreign language, mathematics, science, and social studies" are "particularly limiting for smaller schools." These, alas, cannot afford to offer both the fundamental courses that scientists, scholars, and citizens believe in, and also the gilded fripperies after which the new pedagogues hanker. The lever for prying the schools loose from all intellectual requirements has at last been found. It is the new guiding principle that the Curriculum Program advances: "Since the high school carries the responsibility for educating all youth, it, and not the college or university, has the responsibility of specifying the content of the high school curriculum."[10]

Uncontrolled discretion will at last be vested in up-to-date school administrators like the author of the following remarks, which were addressed to the National Association of Secondary-School Principals and published in its official proceedings:

> Through the years we've built a sort of halo around reading, writing, and arithmetic. We've said they were for everybody . . . rich and poor, brilliant and not-so-mentally endowed, ones who liked them and those who failed to go for them. Teacher has said that these were something "everyone should learn." The principal has remarked, "All educated people know how to write, spell, and read." When some child declared a dislike for a sacred subject, he was warned that, if he failed to master it, he would grow up to be a so-and-so.
>
> The Three R's for All Children, and All Children for the Three R's! That was it.
>
> We've made some progress in getting rid of that slogan. But every now and then some mother with a Phi Beta Kappa award or some employer who has hired a girl who can't spell stirs up a fuss about the schools . . . and ground is lost. . . .
>
> When we come to the realization that not every child has to read, figure, write and spell . . . that many of them either cannot or will not master these chores . . . then we shall be on the road to improving the junior high curriculum.
>
> Between this day and that a lot of selling must take place. But it's coming. We shall some day accept the thought that it is just as illogical to assume that every boy must be able to read as it is that each one must be able to perform on a violin, that it is no more reasonable to require that each girl shall spell well than it is that each one shall bake a good cherry pie. . . .
>
> When adults finally realize that fact, everyone will be happier . . . and schools will be nicer places in which to live. . . .
>
> If and when we are able to convince a few folks that mastery of reading, writing, and arithmetic is not the one road leading to happy, successful living, the next step is to cut down the amount of time and attention devoted to these areas in general junior high-school courses. . . .
>
> One junior high in the East has, after long and careful study, accepted the fact that some twenty per cent of their students will not be up to standard in reading . . . and they are doing other things for these boys and girls. That's straight thinking. Contrast that with the junior high which says, "Every student must know the multiplication tables before graduation."

> Such a requirement attaches more importance to those tables than I'm willing to accord them.[11]

There are even more pernicious strongholds of intellectualism than the junior high schools. But the professional educators, undaunted, are preparing to reduce them. Colleges and universities still resist, but blueprints have at least been made of future institutions of higher learning after the educators shall have purged them. There has been at least one dress rehearsal in Michigan, described in a volume entitled *A College Curriculum Based on Functional Needs of Students*. Here is an enthusiastic report of the work in college mathematics:

> Originally there was no time set aside for instruction in mathematics except a small amount for remedial work on the simple, everyday uses of addition, subtraction, division, multiplication, and other fundamental operations. With the development of other fields of instruction certain abilities became necessary: ability to interpret and make graphs, profiles, charts, and tables; ability to interpret test scores; understanding of certain statistical terms; ability to use the other skills necessary to the general curriculum. . . . This has led to the setting-aside of two hours each week throughout the Freshman year when the student can go to the mathematics laboratory to work, under the supervision of an instructor, on his own inadequacies in the field.[12]

This program was doubtless adequate to accomplish the ends of higher education as these educators conceived them, for in their comprehensive list of the "functional needs" that a college education should serve appears the following high objective: "Ability to read long numbers and to 'round them off.' "[13]

Professional educators are fond of talking about the complexity of modern problems. They speak oracularly of "education for the atomic age." And *this* is how they propose to train citizens to cope with the vast technical questions that are posed by science, by an intricate industrial system, and by international anarchy. After nine full years of formal schooling a student need not be expected to read his native language or to know the multiplication table. And in college he is doing well if he can "read long numbers and . . . 'round them off.' "

Where did these preposterous ideas come from? Who originated them, and who is propagating them? They are obviously not the ideas of scientists, scholars, and professional men. The evidence that the public supports them is manufactured evidence. Under compulsion from their administrative superiors a few public school teachers have given approval, but a number of able and courageous classroom teachers are expressing the sense of outrage that vast numbers of their intimidated colleagues undoubtedly feel. None of these groups can be held responsible for the anti-intellectualism that is wrecking our public schools.

There is no mystery about the source of these proposals. By checking the list of authors and studying the rosters of sponsoring committees, one can fix responsibility, clearly and unequivocally, upon three closely connected professional groups. First of all, there are professors of education, so-called, in universities, colleges, teachers' colleges, and normal schools. Second, there are school superintendents, principals, and other local public school administrators and supervisors. Third, there are state and federal officials and bureaucrats. These three groups constitute an interlocking public school directorate. Collectively, they glory in the title of "professional educators."

The existence of a vast educational bureaucracy is unavoidable, given the size and complexity of the American public school system. But that such a bureaucracy should have usurped the power of making educational policy, as well as administering it, is a catastrophe for which scholars are partly to blame. They have failed to exercise constant vigilance over developments in the public schools, and to bring their views on the subject forcefully to public attention. They have allowed college entrance requirements to be relaxed. They have permitted professors of education to seize control over the college programs of students preparing to teach. They have failed to provide continuous, organized intellectual leadership—completely independent of the pedagogues—in the process of developing and strengthening the secondary school curriculum.

Into the breach have rushed the "experts" from state departments and colleges of education, the curriculum doctors, the integrators, the indoctrinators—the specialists in know-how rather than knowledge. Out of their overflowing minds they have offered to furnish ready-made a philosophy to guide the entire educational system. They are glad to point out to the teachers—those unimaginative dullards—the relationships that exist among the great fields of knowledge. They are happy to draw the really vital generalizations from the data which grubbers in laboratories and libraries have so obligingly collected. All that teachers need do is teach what they are told to teach. All that scientists and scholars need do is supply little facts to fill up the blanks in the great schemata which the educators have devised. "We have decided to teach a unit on industrialism," they say to the scholars. "Will you as a historian assist us by telling us who invented the power loom? And will you as a

scientist show us how to connect up a buzzer?"

Consider for a moment the training and qualifications of the men who have seized this stranglehold upon American intellectual life. The professional educator does not ordinarily hold an advanced degree in one of the established scholarly disciplines, but merely in the teaching of them, or in the supervising and administering of school systems. His advanced degree (and often his undergraduate one) is granted by a department of education or a teachers' college. If a doctorate, it may be an Ed.D.—a doctor's degree with the teeth pulled. Although he may consider himself a specialist in the teaching of some particular field, he is apt to define the field itself in vague terms: not history or economics, but "social studies;" not physics or botany, but "general science;" not English or German, but "language arts." His training in the various parts of his omnibus field has been kept to a bare minimum in order that he may take full advantage of the rich variety of courses which the professors of education offer: "Supervision in Home Economics Education," "Public School Business Management," "Elementary School Core Programs."[14]

Throughout his entire career the professional educator can have only the most fleeting glimpse of the great world of science and learning. At worst he may have no contact with it at all. His first twelve years of schooling are in a system run by the educators. His undergraduate work may be done in a normal school or teachers' college, dominated again by the educators. If he is fortunate enough to receive his undergraduate training in a college of liberal arts, teacher certification requirements may reach out to thwart him, diverting his effort to pedagogical trivialities at the very moment when he is ready to buckle down to serious advanced work in one of the disciplines. The graduate work of the future educationist is directed by professors of education, and most of it must be taken in courses labeled "Education." His professional life is apt to be lived in close association with the educational bureaucracy and in an isolation, largely self-imposed, from the realms of scientific and scholarly research and higher learning.

Across the educational world today stretches the iron curtain that the professional educators have fashioned. Behind it, in slave-labor camps, are the classroom teachers, whose only hope of rescue is from without. On the hither side lies the free world of science and learning, menaced but not yet conquered. This division is the great reality that every citizen must recognize and understand. The subversion of American intellectual life is possible because the first twelve years of formal schooling (from the elementary grades through the high school) have fallen under the policy-making control of educators who have no real place in—who do not respect, and who are not respected by—the world of science, of scholarship, and of the learned professions.

The fifth column that engineered this betrayal was composed of professors of education. When they were given university status, they were expected to assume the role of mediators. As members of an academic community they were supposed to grasp the growing complexity of intellectual life and to see its implications for secondary education. As teachers of teachers they were expected to translate these developments in science and scholarship into the language of the classroom. Through their close connections with school administrators they were expected to develop curricula more thorough and rigorous than those of the slipshod past. Their great responsibility was to stimulate and encourage rising standards of disciplined training throughout the school system, using the prestige of their university position to advance the ideals of liberal education to which the university is dedicated.

Professors of education have failed—nay, have refused—to do any of these things. There are honorable exceptions, of course. But, by and large, professors of education have never undertaken to transmit to the public school bureaucracy the considered educational views of their scholarly and scientific colleagues. Instead they have arrogated to themselves the sole right to speak, in the name of the university, on matters of public school policy. They have used the prestige of the university not to advance but to undermine science and learning in the schools. And they subject to personal vituperation any colleague in the liberal arts who ventures to protest.[15] In their eyes a lifetime of teaching cannot make a scholar or scientist anything but a meddlesome amateur when public educational policy is up for discussion.

Professors of education as a group have made their choice, and their rewards have been tangible ones. They have sold their position in the learned world for a partnership in the public school directorate. They serve their partners faithfully, laboring assiduously to enhance the power of the educational bureaucracy and to free it from the last vestige of responsibility to the world of science and learning. In return, the public school directorate renders valuable assistance to departments and colleges of education in building up their empires

within the universities. Teacher certification requirements, fixed by the state educational bureaucracy, insure a steady flow of students through the courses given by professors of education. Experienced teachers who return to the university for advanced work are all but compelled by their administrative superiors to take that work, not in the subjects they are teaching, but in endless courses in pedagogy. The inflation of departments of education that results from this ingenious protective tariff is illustrated by the situation at the University of Illinois. There a graduate faculty of twenty-eight full professors of education offer no less than seventy-five courses at the highest graduate level, whereas eighteen full professors of chemistry offering less than half as many courses of equal rank (thirty-four to be exact) suffice to make the Department of Chemistry and Chemical Engineering one of the great centers of research and advanced scientific training in the United States.[16]

If the workings of the great public school directorate are called in question at any point, an educational survey can be initiated, and the educators then cheerfully investigate each other, like a treasurer auditing his own books.

Can we afford to entrust to men who think and act like this the power to direct the first twelve years of American schooling? Can we build a skyscraper by commissioning architects and engineers to erect the superstructure, while leaving the foundations to be planned by a crew of bricklayers who do not believe in buildings more than three stories high? The years from six to eighteen are the years in which young men and women must learn to think clearly and accurately if they are to learn to think at all. Command of written English, foreign languages, and mathematics—to say nothing of the abstract processes of analyzing, generalizing, and criticizing—cannot be acquired in a year or two when a student or a citizen suddenly finds himself in desperate need of them. The seed must be planted at the beginning and cultivated continuously if the crop is to be ready when it is required. And these intellectual abilities *are* required, not merely as a prerequisite for advanced study, but also and especially for intelligent participation in the private and public affairs of a world where decisions must be made on the basis of informed and accurate thinking about science, about economics, about history and politics.

The disciplined mind is what education at every level should strive to produce. It is important for the individual. It is even more important for society. It is most important of all for a democratic society. In that terrifying novel by George Orwell, *1984*, the Party of Big Brother developed the ultimate in ruthless dictatorship precisely because it devised the means of enslaving men's minds. It began by undermining the discipline of history, setting all men adrift in a world where past experience became meaningless. It continued by undermining the discipline of language, debasing speech until it could no longer be the vehicle of independent thought. And the crowning triumph of its torture chambers was the undermining of the disciplines of logic and mathematics, by which it finally brought its victims not only to assert, but actually to believe, that two plus two equals five.

Fortunately it is as yet only through fantasy that we can see what the destruction of the scholarly and scientific disciplines would mean to mankind. From history we can learn what their existence has meant. The sheer power of disciplined thought is revealed in practically all the great intellectual and technological advances which the human race has made. The ability of the man of disciplined mind to direct this power effectively upon problems for which he was not specifically trained is proved by examples without number. The real evidence for the value of liberal education lies, where educational testers and questionnaire-makers refuse to seek it, in history and in the biographies of men who have met the valid criteria of greatness. These support overwhelmingly the claim of liberal education that it can equip a man with fundamental powers of decision and action, applicable not only to boy-girl relationships, to tinkering hobbies, or to choosing the family dentist, but to all the great and varied concerns of human life—not least, those that are unforeseen.

When Americans, a century or so ago, committed themselves to the ideal of universal democratic education, they were not thinking in terms of the trivia that fascinate present-day educators. They did not intend, by making education universal, to debase and destroy it. They were not seeking to water down the great tradition of disciplined and liberal study. They were undertaking the heroic task of raising an entire nation to the highest attainable level of intellectual competence. Liberal education, they believed, was not and should not be the exclusive prerogative of the aristocratic few. Even the humblest man, whatever his trade, was capable of a liberal education. In a democracy he was entitled to it. His intellectual horizon should not be limited, as it had been for the lower classes in times gone by, to his occupation and to the routine details of his everyday life. He should receive training for his occupation, true. But far more important than that, he should be

given an opportunity to develop his mind to the fullest extent possible. He should be given command of the intellectual resources that had once been the badge—and one of the principal bulwarks—of aristocracy. His mind furnished with the knowledge and disciplined to the strength that had made the old ruling classes great and powerful, the American freeman would be in a position to rule himself. And the civilization he built would be a humane and magnificent civilization because it offered to every man not only equality before the law, not only the right to vote and to work, but, most precious of all, the opportunity to develop through liberal education his own highest qualities of manhood.

Let us never be satisfied with less.

### Bibliography and Notes


1. Padover, S. K., Ed. *Thomas Jefferson on Democracy.* New York: Penguin Books, 89, 149, 87, 90, 118, 90 (1946).
2. Reeder, E. H. The Quarrel between Professors of Academic Subjects and Professors of Education: An Analysis. *Am. Assoc. Univ. Professors Bull.* **37,** 514 (Autumn 1951).
3. Illinois Secondary School Curriculum Program. Bull. No. 11, *How to Conduct the Follow-Up Study,* 30 (Aug. 1950). The printed text lists only 55 problems, but all the accompanying statements speak of "56 real-life problems" (*ibid.,* 11). The unexpressed 56th problem—insoluble, perhaps—is doubtless that of summing up correctly the following figures: 6 + 10 + 5 + 3 + 12 + 7 + 4 + 8.
4. ———. Bull. No. 13, 15, 14.
5. ———. Bull. No. 1, 10.
6. *Ibid.,* 35.
7. ———. Bull. No. 11, 33.
8. *Ibid.,* 10 (italics omitted). Note also the following statements: "The central purpose underlying the use of this questionnaire is precisely that of securing factual evidence which can be used to persuade a larger proportion of the pupils, teachers, and school patrons of the necessity of thus functionalizing the high school curriculum" (p. 13); repeated almost verbatim on p. 27: "If, on the other hand, such a consensus [in favor of a "real-life" curriculum] does not exist [in the answers to a given questionnaire], it is apparent that the data afforded by the other questionnaires . . . will afford the basis for engendering the requisite consensus" (p. 28).
9. ———. Bull. No. 1, 25.
10. ———. Bull. No. 9, 14, 5, 13.
11. Lauchner, A. H. How Can the Junior High School Curriculum Be Improved? *Bull. Natl. Assoc. Secondary-School Principals,* **35,** (177), 299 (Mar. 1951). In reprinting this passage I have made and indicated a few omissions at the end of paragraphs. The three dots that occasionally occur in the middle of sentences, however, are not marks of ellipsis but are the author's substitutes for traditional punctuation. Mr. Lauchner, at the time of reading this paper, was principal of the Thornburn Junior High School in Urbana, seat of the University of Illinois. Although his remarks were fully reported in the local newspapers, and have subsequently been cited several times, no member of the faculty of the College of Education of the university has publicly expressed an adverse opinion of them.
12. Heaton, K. L., and Koopman, G. R. *A College Curriculum Based on Functional Needs of Students.* Chicago: Univ. Chicago Press, 64 (1936). This volume reports an actual experiment involving the Central State Teachers College at Mount Pleasant, Mich.
13. *Ibid.,* 148.
14. These are three of the courses currently offered *at the highest graduate level* by the College of Education at the University of Illinois.
15. In reply to the article entitled "The Emperor's New Clothes" (*Sci. Monthly,* **72,** 32 [1951]), by Harry J. Fuller, Ph.D., professor of botany in the University of Illinois, a public address was given by Willard B. Spalding, Ed.D., LL.D., dean of the College of Education in the same university. It was entitled "The Bewildered Botanist," and in it Professor Fuller was described as "a peripatetic hatchet man," "a demagogue rather than a scholar," "a master of the pointed phrase rather than the finished thought," a writer whose article was completed with "a satisfied leer," and a man who "reveals either an almost unbelievable ignorance of sociology, or an indifference to social well being that is beyond . . . comprehension" *Champaign-Urbana Courier* (Jan. 9, 1952).
16. *Univ. Illinois Bull.,* **48,** (16), (Oct. 1950), *Graduate College, 1950–1952,* 73, 106.




# Disagreement: The Situation of Reason

MARTIN S. DWORKIN

*The author is a professional writer and editor, one of the few ever to make an appearance in the pages of* THE SCIENTIFIC MONTHLY. *He received his graduate training at Columbia University and the New School for Social Research, and has published widely in many kinds of magazines, both serious and not so serious.*

THE problem of disagreement among philosophers is in one sense the problem of philosophy. This has long been recognized by theologians of the three great Western faiths, who have been able to cite the fact of disagreement as evidence of the inefficacy of human reason depending only upon its own resources. Nor can this argument be turned, like a petard, to hoist its proponents. For to point to the multiplicity of religions as demonstrating the inadequacy of religion is to beg the question, from the vantage of any particular theology. Each religion makes claims upon its adherents which render the possibility of truth in other faiths at best a purely intellectual construction. Catholicism has recognized this, from its beginnings to Aquinas, to the Syllabus of Errors of 1864, to the unequivocal position of the Jesuit organ *La Civilita Cattòlica* in 1948. There can be no salvation outside a faith the essence of which is precisely that it is the one true faith. Those religions which, under the impact of a pluralist democratic development, have admitted to others the possibility of truth and salvation have truly debased their most precious metal to an alloy whose value as currency resides no longer in an intrinsic religious truth, but in a pragmatic criterion of acceptance. They become, as the Catholic protagonist in Santayana's novel puts it, denials of faith, ". . . backslidings into heathenism; they deny in some measure the supremacy of the human heart, and of the supernatural: and in that measure they lead back, covertly but inevitably, to the heathen highway of a feigned conformity and a real despair"—*The Last Puritan* (New York: Scribner's, 190 [1936]).

The philosopher holding for reason against revelation has the burden of proof placed upon him, despite the fact that what has been revealed, how, and to whom differs from religion to religion. And what he must needs offer are not only the fruits of his own learning and speculation, but the history of thought as well: a history of starts and counterstarts, doubts and counterdoubts, truths and countertruths. The theologian regards the discordant chorus insisting that reason is harmony and deduces the necessary existence of a higher realm of faith and a higher science of theology. The philosopher hears the arguments of those about him and stops to wonder. He may then retreat into a theology, although this, perhaps, will go by the name of "philosophy"—dogmatic, exclusive, locating every other view as some form of error. Or he may doubt every voice, including his own—as did the Pyrrhonists—denying even the rational process that led him to his doubt. Or he may say, "We must go back, to the utter beginning, and begin again." Socrates despairs of the conflicting views of natural science of his day, and concludes that he "has no head" for such things—euphemistically justifying his setting out upon his own, radical, speculations. Descartes, with one eye to the omnipresent Inquisitor, determines the "reformation" of his own opinions; and while denying that the houses of the town must be leveled before they can be built anew in the true pattern, yet by his methodological doubt wrenches loose not only their worldly foundations, but the very newel post of the staircase to heaven. And Husserl claims for his own radical beginning into phenomenology that it fulfills the Leibnizean prefigurement of a universal ontology, that it restores the ancient conception of philosophy as the universal science, that it makes possible the only "objectivity" about which there can be no disagreement.

The student and the lay wayfarer among the paths of ideas must somehow locate themselves with

respect to this fact of disagreement. Here it may prove of value to recur to the problem of the audience in Plato's dialogues. It will be recalled that Socrates only ironically desires to convince Thrasymachus. The latter is left behind early in *The Republic,* since the first concern of the great teacher is with the two young men, Glaucon and Adeimantos: a concern that dramatically personifies Plato's purpose to persuade the omnipresent audience, observing and participating in the dialogue. Socrates' irony is lost upon Thrasymachus—as, in other dialogues, upon Euthyphro and Meno, Gorgias and Protagoras—but it is not lost upon the audience. It is for the benefit of those who desire to learn and can yet do so that reason is weighed against unreason, truth against falsity, justice against injustice, reality against appearance. That Thrasymachus remains adamant is only symbolically relevant: as the doctrine that justice is power cannot yield, of course, to any merely reasonable way of determining truth and right. Nor is it relevant for the success of the method of dialogue that Protagoras ostensibly ends up defending a view he first held indefensible. Paradox becomes dramatic instrument in the hands of persuasive purpose. The unconvinced character in the dialogue is revealed not as a representation of unresolvable dilemma and indecision, but as an exemplified alternative, held up for scrutiny on the part of the participating observer.

That the various protagonists in the vast, unauthored "dialogue" of the history of thought do not agree defines the problem, and not the defeat of reason. The theologian, who is committed only provisionally to philosophy, may withdraw into the formal confines of his faith as a defense against the variegation of philosophical alternatives. This recourse to an ostensibly superhuman realm may be as human as any other effort at explaining the world. But the premise of religious faith repudiates such humanistic characterization as a begging of the question: since the supernatural object of faith is very real to the believer, and not merely a congenial fiction. That there is one truth to the adherent of any particular religion, and many philosophies, is the ineluctable circumstance of reason—providing a continuing ground for entering a caveat against what can become an overweening admiration for philosophical method.

For it is often argued, from one philosophical vantage or another, that the persistence of many issues in the agorae of debate is attributable to nothing more than that the protagonists will never admit that they are wrong. Such an argument builds upon an implicit assumption of a universal methodology, to whose canons all must perforce adhere. It is true that the search after such an all-coercive discipline for reason has occupied thinkers since the very beginnings of philosophy—a fact which, in itself, ought to give pause to the most sincere enthusiast for any particular view. The most rigorous discipline for reason, however, cannot exhaust those more than simply intellectual requirements and potentialities which are so involved in the very nature of the human being.

The most stringent principles of logic, for example, are most fruitfully conceived as invaluable instruments. When applied they may discover inconsistencies of tenet or statement, and thereby can prejudice acceptance or rejection; but they cannot necessarily ensure the alteration of conviction.

In the course of being convinced, or of "changing his mind," a person is involved to an extent transcending the simple opposition of logical alternatives. He is a whole person, with a unique and inescapable past, and not simply the part of his psyche responsive to logical ordering. Although his private attitude may be of only ancillary relevance so far as the purely logical validity of any statement is concerned, it is of the first significance to anyone whose concern is to communicate with him. Choice from among contending alternatives is a matter of conviction; a person chooses one or another for reasons, and not simply as the creature of an inevitable momentum that alone determines which way he will go, and when. A principal reason for a particular choice may be the logical structure of the proposition being chosen: a fallacy or inconsistency discouraging acceptance on the part of one to whom logical order has become important. Philosophical method is neither innate nor inevitable; like most of the other methods by which man attempts to explain and contend with the world, it must be learned—and believed in.

That there is one philosophical method or body of doctrine before which all others must yield, and which will confront and defeat religion once and for all time, is a conception as dogmatic as any it desires to supplant in the name of free reason. The battle of philosophy against blind faith must be joined now, to be sure; but it must go on for every *now* in the future: for the *now* of every individual who will ever have to choose. If there is a creed to which men of reason may subscribe, a testament for such a humanism that is to be free of self-delusion as to its real humanity, it is the belief set down so long ago by Heraclitos: that the boundaries of the human soul cannot be reached, no

matter how far one may travel, in any direction.

It is the religious claim—and that of many schools of philosophy as well—that the superorganic limits of the human may be known, since they have been immutably fixed, whether by creation or natural condition. But a religion, no more than a science or a philosophy, cannot predict the bounds of man's knowledge of himself, and of what he may become. For in creating or believing in a religion, a science, or a philosophy, man extends himself beyond the point personified by the necessity of seeking such particular religious or reasonable solutions. As he asks "Why?" of some particular faith, fact, or idea, he leaps beyond the point where he had stopped before; as he doubts and explains his choices to himself, he comes to need new and more powerful beliefs and disciplines. Religion evokes meta-religion, science meta-science: every stage and every system must be seen in turn by some larger, more encompassing view, in order to be fully realized in scope and limitation. Nor is this surging and heaving inherently progressive or meliorative for humanity at large. Every human person is at once the contemporary of the darkest ignorance and savagery of which man is capable and of the highest knowledge man has achieved up to his time. And these areas are not safely discrete, and easily distinguishable; man's evil and his good interpenetrate each other in his society and his selfhood, and are torn apart and made distinct only at points of choice, and only with great difficulty.

At any stage, an explanation that is contemporaneously acceptable may be institutionalized, and supplied with such coercive strictures as to require catharsis for the process to go on. The lines of battle are always drawn, however, and the conflict is eternally joined. Neither religionist nor humanist can prevent the struggle for long. Canons and cathedrals may be raised, rules and procedures made into such dogma as requires a priesthood and blind faith; the human will ever question, and in questioning seek some way beyond these limits to overleap the walls into liberating—and terrifying—dimensions where he has not been before.

As the great, uncharted dialogue goes forward, as alternative confronts alternative and yields or is transformed to rise again, the issue of disagreement is seen as not simply one of controversy, but of conviction: of the perennial attainment of individual convictions. Each particular person must be met, and given reasons why he should choose one view rather than another. A doctrine conceiving its own validity as absolute, necessary, and exclusive does not in its very nature take into account the vital uniqueness of individual personhood, that can choose for itself, to be more truly itself. For the protagonist of any particular view, his must prevail; for the philosopher, reasonable commitment must triumph over blind belief. But the opponents and the theologians will be left always upon the field—to be fought anew, again and again, before the ever-present gallery of those who must choose.

## THE RIDDLE OF THE SKIES

(The Perseids Appear about August 15)

Slashed by the earth the comet's orbit glares
With tiny meteors; each fiery tail
Now into incandescence sparks and flares
In earth's rare upper atmosphere . . . exhales
And burns to cosmic dust. So wise we are,
No more we speak of "shooting stars" whose trails
We glamorized with zeal. Now scan each star
And measure its velocity! Now seek
For clues! But out from wonder, stretched afar,
They into wonder go; the clues are weak,
Themselves burnt out. With old allies
New mysteries are wheeling; they bespeak
No answer to the riddle of the skies. . . .
And stardust still lies heavy in our eyes.

*Kansas City, Kansas*

Florence Holcomb Martin

# SCIENCE ON THE MARCH

## THE ROLE OF GEOPHYSICS IN EXPANDING MINERAL PRODUCTION

THE title of this article will be misleading to those who read into it the narrow, popular interpretation of the word geophysics to mean geophysical prospecting, or an implication that I am referring only to expanding the mineral production of the United States. The introduction of the term geophysics far antedates the practice of the art of geophysical exploration, and at the time of its origin some hundred years ago, it meant the broad science of the physics of the earth. That is still, fundamentally, what the word connotes and it is with that connotation that I am now using it. I also wish to consider from a broad point of view the growing desperate need to increase the world's production of mineral resources.

In examining the role that the mining industry plays in our civilization, we must look not only within our own national boundaries, but view the world as a whole, as an integrated entity. No nation can hope to find, within those artifical, political borders that have been created as a result of man's combativeness, all the natural resources needed for its welfare. In fact, the welfare of the United States will depend not only on the natural resources that it possesses within its own borders, but in a very real manner it will rest upon the natural resources that may be found and exploited in every part of the world. This does not mean that any country can or should expect to exploit and deplete the resources of other peoples in order to satisfy its own industrial demands. It does mean, however, that the future security of North America will depend directly on the well-being of the people of all the other great areas of the world.

The economists and the humanitarians, the statesmen and the politicians, have long been insisting that an empty belly and a frustrated yearning for a better life provide a fertile ground in which to plant the seeds of hypocritical promises of Utopia, so widely sown by the Russians. This thesis is hardly to be denied, and the democratic world is faced with the task of providing the deeds, of food and industrial development, to counteract the cynical promises of the dictators. Our standard of living is the envy of the world, and the rulers of the Kremlin are probably the most envious of all. The improvement of the well-being of the rest of the world must come from North America.

The President's *Report on the Economic Condition of the Nation* sets forth our gains in living standards and emphasizes five important consumer fields. Three of them furnish interesting criteria of consumer demand, pertinent to the mining industry, because of the metal consumption involved. These are electrification of farms, ownership of automobiles, and use of electric refrigerators. Seventy-five per cent of U. S. homes possess electric refrigerators, and 80 per cent of all American farms have electricity. There are roughly 30 passenger cars per 100 persons in the United States, which probably means that, on a family basis, some 60–80 per cent of the population has the use of an automobile. Such statistics from Russia are conspicuous by their absence, but enough information comes from behind the Iron Curtain to warrant a guess that the corresponding figures would probably be a tenth or less of those applicable here. From the point of view of the diversion of industrial capacity to military preparedness, the Russian people therefore have far less to lose, far less to sacrifice than we. A serious cutback in the type of goods and services mentioned would mean a sacrifice of no mean proportion in our ever-rising standards. In Russia, on the other hand, it would take but a small industrial capacity devoted to such goods and services to increase their minute output and thus raise the living standards of some of the people, at least in certain quarters. Keep in mind that this same situation will apply in many parts of the globe where, were Russia to gain dominion, she would find it comparatively easy to stage a semblance of bettering the welfare of some of the people (at least of the Party *fonctionnaires*).

This is the situation which challenges us to the limits of our industrial capacity, and beyond. I shall not stop to figure out how many motor cars or how many refrigerators would be needed to supply the rest of the world at the same ratio that we enjoy, but it may be noted in passing that the population of the United States is about 6 per cent of the world population. So, to arrive at a rough figure, multiply the industrial output of the U. S. by 15 to determine what the world demand would be were it to consume goods at the same rate. Concrete figures of metal requirements, however, will highlight the problem effectively. For the figures cited below, I am indebted to Elmer W. Pehrson, chief of the Foreign Minerals Division of the U. S. Bureau of Mines. He presented this problem and these figures before the United Nations Scientific Conference on the Conservation and Utilization of Resources in New York City in August 1949. A study of the

per capita consumption of some selected metals will demonstrate the overwhelming problem of the mining industry if the rest of the world is to be brought anywhere near our own living standard.

For example, in 1947 the per capita consumption of iron in the U. S. was 335 kilos. Assuming a world population, in round figures, of 2,300,000,000 we find that the global requirements of iron would come to the stupendous figure of 770,500,000,000 kilos per year, or 770,500,000 metric tons, which, for rough figuring, may be considered to be the equivalent of long tons. The reserves of the great Cerro Bolivar iron deposit in Venezuela, hailed as the greatest discovery of the century, were recently estimated at half a billion tons of ore. The above requirements of iron (not iron ore) would necessitate the discovery and exhaustion of just about two Cerro Bolivars per year!

Similar figures apply to copper. Our per capita consumption in 1947 was 8.2 kilos. At that rate the world would require an annual output of 18,860,000,000 kilos, or approximately 18,860,000 metric tons of copper. Who can at present foresee a source for such a colossal requirement? The world-wide output of copper in 1947 was only 2,200,000 metric tons of the metal. The world reserves were estimated at that time to be 100,000,000 metric tons, enough to last five years were it consumed at the rate postulated.

The per capita consumption of lead and zinc in the United States in 1947 was at a nearly equal rate for the two metals—4.7 kilos for lead and 4.9 kilos for zinc. For easy calculating, we can assume a figure of 5 kilos for each metal and arrive at a requirement of 23,000,000 metric tons per year for the two metals combined. The world's annual production of lead in 1947 was 1,200,000, and of zinc in 1948, 1,800,000 metric tons. Ignoring the one-year difference between the figures, the annual consumption of the two metals would be 3,000,000 metric tons, or about one eighth of the above requirement. The world reserves of lead and zinc in 1947 or 1948, as estimated by E. W. Pehrson, amounted to 110,000,000 metric tons. The requirement above-cited would exhaust such reserves in five years.

The story is repeated for other mineral resources, but let us take a look at only one more—oil. The per capita consumption of petroleum in the United States for 1947 was 13.8 barrels, whereas for the world as a whole it was only 1.3 barrels. Therefore, the world's annual production of petroleum would have to be increased *tenfold* if the people of Europe, Asia, Africa, and South America are to drive around in motor cars to the same extent that we gad about, heat houses with fuel oil (as is done in the northern United States and Canada), enjoy to the full the fascinating uses of plastics, and clothe themselves in nylon, rayon, and other synthetic fibers such as are pouring from our factories.

That, then, is the problem before the mining industry: how to increase the production of mineral resources so that the peoples of the world can enjoy some of the comforts and advantages that people in the United States take for granted, and even remain abysmally ignorant of the pitiful living conditions under which a large part of their fellow human beings exist.

That the genius of the chemical engineer will eventually produce synthetics which will replace metals for many uses, I do not doubt. When this will happen and to what extent, no one can foretell, but unless such synthetics replace metals almost entirely, the mining industry will be confronted with its greatest challenge.

How will this challenge be met?

In his annual review of mining geology, published in *Mining and Metallurgy* (1947), Carlton D. Hulin said:

> So far as concerns geology, the problems of intensified ore discovery demand less in the way of new theories and new techniques than in the rigid and critical evaluation of our existing knowledge of ore deposits. . . . Those concepts that meet the acid test imposed by basic scientific principles and known factual data, properly welded together into a coherent whole, are capable of meeting the needs of ore discovery. An adequate evaluation of structural dynamics; a proper appreciation of the dynamically changing physical-chemical system which is evidenced by the progressive sequence of mineral introduction and by successive wall-rock alteration; a fundamental understanding of the factors involved in zonal deposition, particularly an understanding of the barren zone known to overlie the productive horizon of most mineral deposition; and fully-detailed interpretation of the chain of events induced by supergene agents; these, properly integrated and applied, will satisfy the basic requirements of ore discovery.

To which may be added another quotation from the same article: "It will require all that geology is able to offer, working hand in hand with geophysics and geochemistry, and accompanied by the bold investment of venture capital."

The above concepts now remind us of the broad definition of geophysics given in the introduction. Geophysics may be further defined as the offspring of the marriage of geology and physics, including physical chemistry. Every mineral, every rock on the earth's surface and within its crust, has had its origin in physicochemical processes. Equally true is the statement that every structure, from the tiniest joint to the mightiest overthrust, is the result

of the action of physical forces the origin of which we are almost entirely ignorant. From the narrower viewpoint of economic geology, every mineral deposit is the result of physical and physicochemical forces acting upon the material from which the deposit was derived, and of physical and chemical forces exerting their influence upon the host rock to provide channels of circulation and loci of deposition.

Our knowledge of the physical and chemical forces that shape the earth's crust is pitifully scant. But, as a sufficient body of knowledge accumulates from field and laboratory, we will begin to have some understanding of the basic factors that control the mineral provinces, the details of ore districts within the provinces, and the minutiae of ore deposition. Armed with this knowledge, the economic geologist-geophysicist will be possessed of a powerful tool with which to study the signs visible on the surface of the earth that may lead him to deeply buried and unsuspected mineral regions.

Upon the heels of this type of study must come the exploration geophysicist, equipped with new and more powerful instruments for the detection of broad types of mineral deposits. He will be using methods that are the logical outgrowth of the physical techniques, old and new, for identifying minerals and aggregates of minerals. From the identifying of mineral specimens in thin section by their effect upon light rays, according to the laws of refraction, we have proceeded to the identification of mineral bodies (rocks) by their effect on seismic waves, according to the laws of refraction. From the ancient use of the magnet to identify magnetic minerals such as pyrrhotite and magnetite, we have developed the sensitive magnetometer to identify rock bodies containing minute percentages of magnetic minerals. From the Jolly balance and its measurement of specific gravity of small specimens, we have graduated to the unbelievably sensitive gravimeter, with which to measure the specific gravity of great hidden bodies of mineral aggregates. From the laboratory knowledge of electrical phenomena, we have learned how to measure and define the electrical reactions of hidden minerals and rocks in the field.

These are the steps that have been taken within the past hundred years. In the accelerated pace of scientific development, which increases in an almost geometric ratio, who can foretell what new physical properties, or what refined measurements of the properties we now use, will be developed to endow the exploration geophysicist with far more powerful tools and to enable him to achieve unique solutions that are now beyond his grasp? The geophysicist of today plays an important role in the search for new mineral deposits by helping to define the boundaries of exploration. It is reasonable to expect that the day is not far distant when, in cooperation with the structural and the economic geologist, he can assist in the discovery of new mineral provinces and districts, and within those districts possibly even put the finger on ore deposits!

The geologist of the future must be trained not only in the art of observation and deduction in the field, but must also possess a sound knowledge of physics, chemistry, and mathematics that will enable him to use them in the field as well as in the laboratory. He must, in short, be a geophysicist as well as a geologist. The discovery of new mineral deposits, so urgently needed to meet the requirements of a world-wide rising standard of living, requires the concentrated and integrated application of every relevant field of knowledge.

I should like to summarize the problem by paraphrasing some remarks made by Elmer W. Pehrson in an address before the annual convention of the Canadian Institute of Mining and Metallurgy held in Ottawa in January 1952. In effect, he said that the long-term view of mineral supplies is one of shortage, as present prices and policies do not provide adequate stimulus for new discoveries, and current increases in production come from old deposits. In other words, we are living off our own fat. Against that background we must realize that the Eastern Hemisphere has greater mineral potentialities than the Western, and that furthermore it is using up its reserves at a much slower rate. Western geologists and geophysicists must, therefore, substantially increase the rate of discovery of hidden ore bodies, if we are to meet the requirements of national survival alone, to say nothing of aiding in the industrial development of our fellow-humans in less fortunate parts of the world.

The problems, immediate and long-range, now facing the mining industry therefore include: (1) how to create a climate more favorable for risk capital to engage in broader and more intensive exploration; and (2) how to furnish the needed stimulus for, and support of, a concentrated program of research in the fields of geology and geophysics, both theoretical and applied. The latter will require faith in the ultimate goal, money to march toward it, stamina to stay with it, sympathy with the problems, and acceptance of the results.

SHERWIN F. KELLY
*Sherwin F. Kelly Geophysical Services, Inc.*
*Wilmington, Delaware,* and
*Geophysical Explorations Ltd., Toronto*

# BOOK REVIEWS

## REGIONAL BOTANY

*Arizona Flora.* Thomas H. Kearney, Robert H. Peebles, and collaborators. viii + 1032 pp. Illus. $7.50. University of California Press, Berkeley and Los Angeles. 1951.

KEARNEY and Peebles have placed botanists under renewed obligation by a thorough revision of their earlier *Flowering Plants and Ferns of Arizona.* So considerably changed is the new and greatly improved work that the publishers have not considered it a new edition (which it is), but have given it a new title. The authorship is mainly to be ascribed to Kearney, insofar as the treatment of particular families or genera was not assigned to specialists, but Peebles had an important part in writing the earlier edition, and likewise contributed the section on the important and difficult family Cactaceae. In working over the latter, Peebles did not have the advantage of consulting the recent second edition of Benson's *Cacti of Arizona,* which did not appear in time, and the contrast in the treatment of the family by the two specialists is striking. Peebles has 15 genera and 72 species. Benson recognized 5 genera and 60 species. Some of the discrepancy is accounted for by certain systematic entities (we should now call them by the newly coined term *taxa*) being treated sometimes as species and sometimes as varieties. The difference is otherwise mainly in the maintenance of Britton and Rose's segregate genera by Peebles, which are left united in the old traditional broad genera by Benson, who, in general, is considerably more conservative in his treatment.

Well-known specialists provided treatments of particular families and genera. S. F. Blake, who contributed a painstaking and valuable treatment of the vast composite family, the largest in the Arizona flora, is the author of approximately 14 per cent of the volume. Jason R. Swallen contributed the grass family, the second in number of species, with another 7 per cent, and 21 other authors collaborated. C. V. Morton appears as the author of the section on ferns and fern-allies, which is, of course, a revision of the contribution to the earlier work by W. R. Maxon.

The present flora provides descriptions of approximately 3370 species of higher plants growing wild in Arizona. This would seem to be an extraordinarily large number for a large and prevalently arid region, but it reflects the great habitat diversity of the state, the high endemism (nearly 5 per cent), and the narrow geographic range of many plants that are not confined to Arizona. There are elevations in Arizona from almost sea level to the 12,600-foot peaks of the San Francisco Mountains, which, with the latitudinal position of the state, allow for the presence of floristic components ranging from subtropical (there is even a single native palm!) to arctic-alpine. These are thrown by Kearney into 12 geographic categories, of which the largest is that of Rocky Mountain plants, nearly 24 per cent. At the other extreme are the 12 species which have their chief distribution in the southeastern United States and are lacking in New Mexico and western Texas. The introductory pages, as would be expected of Kearney, are exceptionally interesting from a phytogeographic and ecological standpoint. His best known early flora, *Report on a Botanical Survey of the Dismal Swamp Region* (1901), set refreshing new standards of ecological and phytogeographic background in American floristic work and is still, after the lapse of over half a century, one of the most highly esteemed works on the local-flora shelf. Kearney's ecology, however, is now of such ancient vintage that he uses a blessed minimum of ecological jargon—hardly more, in fact, than the introduction (following Shreve) of the terms "xeric" (instead of "dry") and "mesic" ("intermediate," but, by ecological irrationalism, intermediate only for moisture relations). It will be remembered that the late lamented ecologist Forrest Shreve wrote the excellent section on the "Vegetation of Arizona" for the former edition of the *Flora,* and it must be hard indeed for any ecologist to remain entirely untainted by the linguistic improprieties of his guild.

The bibliographic work done in connection with the writing of this flora was enormous. Nearly 400 titles are cited that have some direct bearing on Arizona, at least to the extent of citing Arizona distributional records, but even this great number does not include the titles of greatest historical importance by the pioneer writers on the botany of the region. The earlier authors are indeed alluded to in the introductory section on "Botanical Exploration," but their contributions are not found in the formal list of "Literature Consulted," which is therefore by no means a complete bibliography. One notes with surprise no direct reference to Tidestrom and Kittell's *A Flora of Arizona and New Mexico,* nor to Tidestrom as one of the important collectors of Arizona plants during the past fifty years. But Kearney makes no reference either to the collections of himself and his co-author Peebles and does not even mention his own beginnings in Arizona botany and botanical authorship, for way back in 1894 appeared the uncited paper by N. L. Britton and T. H. Kearney, "An Enumeration of the Plants Collected by Dr. Timothy E. Wilcox, U. S. A., and others in Southeastern Arizona During the Years 1892–1894," in the *Transactions of the New York Academy of Sciences.* Kearney was then, at the age of twenty, assistant curator of the herbarium of Columbia University (which was subsequently placed on deposit at the New York Botanical Garden), and this appointment was already his second professional one in botany.

He went to the Bureau of Plant Industry in the same year (1894) and continued with the U. S. Department of Agriculture until his retirement. During the years in Washington he became eminent through his distinguished contribution to plant breeding and to Southwestern agriculture in originating improved types of Egyptian long-staple cotton for the Southwest. His work along this line was in the Southwest, continued for many years, and brought him into direct contact with the flora that he began to study as a student and assistant at Columbia in 1893. Nearly six decades later, at the age of seventy-five, he gave us the definitive results of his continued lifetime interest. *Arizona Flora* is scientifically worthy of his devotion and tenacity of purpose.

In view of the fact that the standard regional floras quickly go out of print and cannot be found even in some of the principal public and institutional libraries of the areas covered, it will be advisable for the Kearney and Peebles *Arizona Flora* to be acquired by the local libraries that should have it before it has to be hunted up and paid for at rare-book rates. It is safe to say that it will long remain standard. The forbidding nature of hundreds of pages of technical keys and descriptions is alleviated for the beginner in systematic botany by a series of 45 excellent pictures of typical habitats and vegetation, which satisfactorily show individual species, as such pictures often do not. They are from photographs by Peebles and are so good that they will whet anyone's interest in what follows. One wishes that the series might be expanded to greater inclusiveness in a separate companion volume to the *Flora*—an "Atlas of Arizona Vegetation." Kearney and all his collaborators are to be congratulated on the completion of a notable addition to the too-small group of currently useful state floras. It will be essential for everyday use by those who need to identify Arizona plants, and must also be consulted by all who are broadly concerned with plant distribution, even if they never see Arizona.

H. H. Bartlett
*Botanical Gardens, University of Michigan*

## THEY WENT TO COLLEGE

*Education and American Civilization.* George S. Counts. xiv + 491 pp. $3.75. Bureau of Publications, Teachers College, Columbia University, New York. 1952.

THIS is the third volume coming out of the studies of the Horace Mann–Lincoln Institute of School Experimentation. It is intended to provide the basic philosophy for the curriculum of America's elementary and secondary schools. And it does this powerfully, clearly, persuasively.

The argument runs briefly as follows. America's schools took on their present pattern and curriculum when we were a society of farmers and tradesmen; today that society has given way before an industrial civilization marked by vast production, growth of metropolitan living, rapid transportation and communication, and a position at the center of the world's affairs. Our materials and methods of instruction, therefore, must be changed to meet this challenge of a world community, wherein all individuals are stretched to their full intellectual stature, all are equal in opportunity and self-respect, all exercise their political liberty by participation in government, all can achieve economic security without slavery, all find an outlet for their creative powers in a civilization both beautiful and enduring.

How is this to be accomplished? By stressing attitudes as well as aptitudes in the training of both teachers and students. The key paragraph is on page 217:

> The essence of any civilization is found in its values—in its preferences, its moral commitments, its aesthetic judgments, its deepest loyalties, its conception of the good life, its standards of excellence, its measures of success, its teachings regarding the things for which and by which men should live and, if need be, die. The issue at stake in the coming years is nothing less than the birth, the death, and the survival of values.

What, then, are the values which constitute the American creed? Professor Counts selects five as the most essential: the ethical standards (not the theology) of the Hebraic-Christian faith, especially love and compassion; the humanistic spirit of the Greeks and of the Renaissance, which emphasizes the dignity of man; our confidence in the scientific method of hypotheses tested by instruments as the safest path to truth; the Roman and Anglo-Saxon rule of law to provide channels for peaceful change in society; and the democratic faith in liberty, equality, and fraternity which came from the eighteenth-century philosophers and the French Revolution.

Obviously these are all excellent values upon which to build a civilization and a curriculum. We would have difficulty in improving upon the list by substitution or addition. Preparation to teach them involves not only considerable study of the history and literature and science of the past, but also making a blueprint for the history of the future.

One of the fresh and valuable features of the book is the repeated contrast between the American faith in all these areas and the Fascist and Communist perversions and denials of morality, human dignity, science, law, and democracy. There is no doubt where the author stands; he detests both Fascism and Communism, but he is not content with America as he finds it. In none of these ideals have we achieved the goal; there is pressing danger that we may lose our sense of mission. Therefore Dr. Counts writes this as a "crisis" book, with many of the accompanying exaggerations—"now or never," "at the crossroads" we must choose rightly or go down in ruin. He also overwrites, repeating himself too often, following the same formula again and again; to my taste, the book would be twice as effective if it were half as long.

Nevertheless, in a day when *God and Man at Yale* and *They Went to College* have emphasized that our educated men and women are high-powered machines without a proper steering wheel, here is a chart and compass which might well guide the navigators of our educational liner. It has nailed down a hundred or

more fundamental definitions of terms which we all use too carelessly. It would serve excellently as a text for a course in educational philosophy, or as the source-book for a dozen commencement addresses.

CARTER DAVIDSON

*Union College*

## FIVE BOOKS ON THE MIND

*Bertrand Russell's Dictionary of Mind, Matter and Morals.* Lester E. Dennon, Ed. xiv + 290 pp. $5.00. Philosophical Library, New York. 1952.

*Play, Dreams and Imitation in Childhood.* Jean Piaget. G. Gattegno and F. M. Hodgson, Trans. x + 296 pp. $5.00. Norton, New York. 1952.

*Psychoanalysis and Group Behavior:* A Study of Freudian Group Psychology. Saul Scheidlinger. xviii + 245 pp. $3.75. Norton, New York. 1952.

*Handwriting.* A Personality Projection. Frank Victor. xii + 149 pp. Illus. $3.75. Thomas, Springfield, Ill. 1952.

*Body, Mind, and Sugar.* E. M. Abrahamson, and A. W. Pezet. ix + 206 pp. $2.95. Holt, New York. 1952.

REVIEWER'S potluck has brought me five books —seemingly with no common denominator except that they all deal with the human mind in one way or another. I'll review them together: perhaps juxtaposition will show something that would not be visible otherwise.

Number One on the list—and in my anticipation—is *Bertrand Russell's Dictionary of Mind, Matter and Morals.* Ah, I say to myself, someone has at last collected all the gems from Russell's writing and made a book like that invaluable *Quintessence of G.B.S.* Unfortunately, I am quite wrong, and my disappointment quickly reaches its zenith as I go through the book. What happened here is simply this: Someone had the bright idea that a book like that ought to sell. So all Russell's writings were put through the wringer, excerpts were made and alphabetized and—*voilà*!—there was the book.

It's a perfect example of a completely useless book. The editor apparently proceeded with no other intellectual guidance than the alphabet, and in consequence the book is a monumental hodgepodge. Poor Bertrand Russell! Here are all the drabbest definitions from his technical and philosophical writings, trifling little chunks torn from the context of his other books, the bare and meaningless bones of his great work without the flesh that makes it alive and kicking wherever you touch it. Unashamed, Mr. Dennon has represented the work of one of the greatest minds of our age by such morsels as "The number of a class is the class of all those classes that are similar to it" and "A series has 'Dedekindian continuity' when it is Dedekindian and compact." Without the slightest scruple he has even included in his $5.00 collection a standard definition of afferent and efferent nerve fibers—cross-referenced—simply because Russell found it convenient to put such a sentence in his *Human Knowledge.*

But enough of this. The book isn't worthy of serious attention.

Next: *Play, Dreams and Imitation in Childhood,* by Jean Piaget. What an entrancing title! It isn't Piaget's, though, who gravely called his book *La formation du symbole chez l'enfant*—for the very good reason that that's what it is about. No romance here, no evocative, poetic description of children's awakening; rather, a dead-serious study of the process of symbol formation. For a quarter of a century, Piaget has written an impressive shelfful of books on mental development in childhood, adding up to a solid contribution to knowledge. This latest one fills a gap, showing that symbol formation is the bridge between sensory-motor activity and the operational forms of thought. All in all, clearly indispensable for those who are following Piaget's work —and rather dispensable for those only generally interested in child development.

Let me add, though, that the book does contain treasures: it is filled to the brim with the recorded sayings and doings of Piaget's own three children—"J.," "L.," and "T."—and I can hardly imagine anything more charming and poetical than this material. Two examples will show what I mean:

> J. collected small handfuls of pine-needles to make an ants' nest. There was the pillow, the blanket, the quilt, the sheets, a hole for the baby, a table, a chair, then the mother and a cousin; there was some macaroni in the cellar. *"The ants* (there weren't any) *sit down here* (she sat down herself). *Granny comes."* Then an imaginary character came in. The next day the game was played again, but it all became a cats' house.
>
> . . . L.: *"Oh, the sun's moving. It's walking like us. Yes, it has little paws and we can't see them.*—Where is it walking?—*Why, on the sky. The sky's hard. It's made of clouds."* Then she discovered that it was following us: *"It's doing that for fun, to play a joke on us, like you when you smoke your pipe and play tricks on us.*—Why like me?—*Like grown-ups.*—Not like children?—*No, it's having a joke like grown-ups.*—But does it know we're here?—*Of course it does, it can see us!"*

Hard to tear yourself away from this, but let's proceed to Number Three, *Psychoanalysis and Group Behavior,* by Saul Scheidlinger. Here we have, in contrast to the Russell "Dictionary," a highly useful book. What Scheidlinger set out to do, and did admirably, is a comprehensive survey of Freudian thinking about group psychology. To be sure, this makes for a book with an unremitting sequence of pages full of "As X says," "Y adds," and "Z points out," but the whole is sound and informative. Group dynamics now has the center of the stage; the work of the Freudians in this area is not too well known: if you're interested in their contribution, this is your book.

Scheidlinger himself may be classified as a Freudian with a mind of his own. He has detachment enough to write (p. 149): "Many of the terms considered basic to Freudian group psychology have not been formulated in such a way as to exclude misunderstanding and ambiguity. To mention just a few, there are the con-

cepts of aim-inhibition, of sublimation, of identification. As a matter of fact, this difficulty extends to the whole of psychoanalytic theory." (Quite a mouthful, that last sentence.) He also appears to be far from hidebound in his own approach to actual cases. In the last few chapters of the book, he breaks away from the pattern of the literature survey and surprises the reader with a number of detailed cases from his own consultant practice in group work with children. The descriptions are clearly stated, with a total absence of Freudian lingo, and the solutions presented make a great deal of sense. Come to think of it, the tail end of the book may be even more valuable to teachers than the main part is for researchers. Too bad teachers aren't apt to see it.

The next item, *Handwriting,* by Frank Victor, is a book saddled with two handicaps. In the first place, graphology still has to live down some of the circus-tent aura it has in this country before it can be accepted as simply another form of projective personality testing; in the second place, Dr. Victor is at odds even with the majority of his fellow-graphologists. His point of view is that all preconceived, fixed patterns of handwriting analysis are misleading and unscientific. What he proposes is a self-contained, flexible graphology that studies a person's handwriting with utter thoroughness and then interprets the findings in whatever psychological terms seem most useful—Freudian, Jungian, Adlerian, Sheldonian, or what have you. This attitude seems logical and scientifically sound, except that it adds so much depth to graphology as to make it downright impracticable—not to mention the fact that Victor's admirably detached eclecticism leads him dangerously close to an unappetizing mishmash of psychological schools.

Faced by the competition of the Rorschach, TAT, and so on, Dr. Victor points out that handwriting analysis has two great advantages over rival projective methods: (1) No foreign "test object" intrudes between the subject and his projection; and (2) the subject's presence for evaluation is unnecessary. True enough. But, on the other hand, what psychologists want are instruments that are fast, standardized, and easy to use for therapy and vocational guidance. I'm afraid graphology, in today's projective-test market, hasn't got what it takes.

Finally, there is *Body, Mind, and Sugar,* by E. M. Abrahamson and A. W. Pezet. This is a popular book, very successfully put together by a specialist in the field and a professional lay writer. The result is pleasing: here is a subject handled with competence and presented skillfully to the general reader. This type of collaboration is becoming more and more frequent; more power to the expert-and-writer teams and to the publishers who produce their books!

The jacket of ***Body, Mind, and Sugar*** is likely to put off any reader interested in serious books. It reeks with sensationalism. This is how it starts:

***Chronic fatigue . . . allergies . . . asthma . . . peptic ulcers . . . rheumatoid arthritis . . . neuroses . . . alcoholism . . . drug addiction . . . insanity . . . suicide . . . murder . . .*** For the estimated ***ten*** to ***thirty*** million Americans affected by these conditions, BODY, MIND, AND SUGAR brings new hope for health and happiness.

To my immense surprise, the book lived up to these claims. It certainly *is* sensational. It does contain cases and cures of all the afflictions mentioned—and even presents one honest-to-goodness murder case that goes far to substantiate the most incredible of the claims on the jacket.

Now what is Dr. Abrahamson's sensational subject? It is the "new" disease of hyperinsulinism. Abrahamson does not claim discovery of that disease; on the contrary, his book is dedicated to Seale Harris, who discovered it in 1924. Cultural lag being what it is, it hasn't made much headway in the 28 years since. I feel sure Abrahamson and Pezet's book will make a difference.

Hyperinsulinism is blood sugar starvation—too much insulin at work in the pancreas, and therefore too little sugar getting into the blood stream. In other words, hyperinsulinism is the exact opposite of diabetes. Clinical hyperinsulinism is characterized by hunger, weakness, fatigue, anxiety and nervousness, crying spells, tremulousness, incoordination for fine movements, and mental disturbances. Subclinical hyperinsulinism brings on fatigue, apathy, loss of zest, a general let-down feeling of aimlessness, a revulsion against the routine of everyday life, and anxiety.

Even this short list of symptoms shows that hyperinsulinism practically amounts to a newly discovered symptom of most common neuroses. And Abrahamson and Pezet go further and show, with an impressive array of evidence, that hyperinsulinism was found in patients suffering from allergies, asthma, rheumatic fever, ulcers, alcoholism, and even, as I have noted, in a confessed murderer. (The jury wasn't impressed by the medical evidence, and the man went to the electric chair.)

The list of diseases associated with hyperinsulinism is identical with the list of those for which ACTH and cortisone have proved helpful—those that have led to the theory that the substances supplied by the adrenal glands are needed to bear up under the stress of living. It seems clear that a balanced emotional life corresponds to an equilibrium between the function of the adrenal glands and the pancreas; any disturbance in the direction of hyperinsulinism is likely to be accompanied by a neurosis and perhaps a psychosomatic illness. (On the other hand, diabetics are happy-go-lucky, a little too carefree, and appear to be immune to asthma, rheumatoid arthritis, and the rest.)

What makes the book sensational is the fact that hyperinsulinism can be cured simply and effectively by following a diet devised by Dr. Harris. The diet (which appears in the book and on the back cover) looks superficially like an ordinary reducing diet—no sweets, no carbohydrates—but differs in several respects, particularly in allowing fats, prescribing between-meal and bedtime snacks, and completely ruling out coffee and anything else containing caffeine.

This is one of the most hopeful books I have read in years. There is a fascination in the wide variety of case histories offered. But none of them is more astounding than the one on pages 122–24, quoted verbatim from a 1950 report by Sidney A. Portis, of the University of Illinois, in the *Journal of the American Medical Association*. It deals with a thirty-seven-year-old executive whom his company had transferred from a large city to manage a plant in a small town. After he had been there four or five years, the management found that the efficiency in the plant had gone down. Why? Because the manager had become bored, tired, chronically fatigued, and generally unhappy—a classic case of hyperinsulinism, as evidenced by a Glucose Tolerance Test chart on page 123. Dr. Portis' conclusion is this:

> What does all this add up to? On the one hand, the business of the plant was conducted more efficiently and production costs were lower than in its previous location. On the other hand, at the end of five years its top executives were distinctly bored and tired and sooner or later became inefficient. Of course management and business must get a fair return on their capital investments or they will not be able to enlarge, modernize or expand their plants. But business should realize that highly developed, highly skilled workers must have some chance for diversion in their life outside the plant. This may mean that management may not profitably locate plants in areas where the labor market is good if the price they have to pay is a breakdown in the efficiency of their top executives.

Here we have, I think, a foretaste of the often-prophesied "unity of science": economics, sociology, psychology, and physiology inextricably combined and brilliantly cooperating to improve the conditions of society.

Have I detected a trend in these five books? Hardly. But I leave them with a feeling of hope. We are getting closer to the solution of the riddles of the human mind—we are graduating from random aphorisms to the analysis of children's games to blood-sugar level tests. The answers are beginning to come in.

RUDOLF FLESCH

*Division of General Education*
*New York University*

## HELMINTHS EXAMINED

*The Zoology of Tapeworms.* Robert A. Wardle and James Archie McLeod. xxiv + 780 pp. Illus. $12.50. University of Minnesota Press, Minneapolis, for the University of Manitoba. 1952.

A CONSPICUOUS gap in the library of every helminthologist may now be filled by this recent publication of the tapeworms of the world. The desirability of such a compilation of data has long been realized, but the writing of such a volume was an ambitious undertaking. The present authors spent approximately ten years in the preliminary collecting of papers, specimens, and drawings and the final drafting of the manuscript. They have attemped to include all known tapeworm information to 1950.

The book is divided into two sections: Part I dealing with the general zoology of tapeworms, and Part II with the classification and taxonomy of the known genera of the world. The anatomical and histological features of tapeworms are carefully described, and the variations in life cycles are discussed in the first few chapters. None of these chapters is bogged with detail—the subtleties of anatomy used in identification are reserved for the descriptive portions of individual genera.

Because present-day experimental emphasis is on the "how" and "why" of tapeworm development and behavior, the chapter devoted to biology and physiology is particularly interesting. The authors believe that

> . . . the study of tapeworm biology concerns two sorts of problems: (1) those that concern the tapeworm as an individual—its growth, activities, alimentation, respiration and so forth; problems, that is to say, of *autecology*; and (2) those that concern the tapeworm as a member of a partnership—its relationships with other parasites and with its host, the effects it may have upon its host, and the effects the host may have upon it; problems, that is to say, of *synecology*.

The greatest single problem in the autecology of tapeworms concerns the successful maintenance of worms outside the host body. Experimental investigations of growth, nutrition, and respiration are handicapped until this initial problem can be overcome. Progress has been made in this area, and recent results offer promise for the future.

Extensive material on the controversial and problematic origin of tapeworms has been assembled by the authors, who suggest several tentative postulates as a basis for future phylogenetic inquiry. A concise history of helminthology is offered at the conclusion of the first section of the book. A second, taxonomic section is introduced by a survey of the development and methods of classification in use today and presents descriptions and keys to the Cestoda genera of the world. Details necessary for identification are extended to species for the North American forms.

The general appearance of the volume is greatly enhanced by the uniformity of the line drawings used, and the junior author is to be complimented for his illustrative contribution. Four hundred and nineteen original plates are interspersed throughout the text. It is regrettable that the economics necessary in the publication of a monograph of this sort necessitated the degree of reduction imposed upon most of the text figures. In many drawings considerable detail has been lost; this is particularly noticeable in the drawings of individual proglottids, where the structural detail is important. However, considering the volume of material that had to be condensed into a reasonably sized (and priced) edition, the publishers are to be congratulated for the number of illustrations that they did incorporate.

Attention should be paid to the extensive bibliography that has been assembled. In it Professor Wardle has consolidated over 3100 references from a literature

scattered in many countries and written in more than five languages.

There is no doubt that this study of the Cestoda of the world will become a classic in the field of helminthology. Its use as a standard reference by all parasitologists is guaranteed. The field of helminthology would be well documented indeed if some equally devoted authors could be persuaded to produce a companion study of the Trematoda.

I. E. STEWART

*American Institute of Biological Sciences*
*Washington, D. C.*

## ADVANCES IN ENDOCRINOLOGY

*Adrenal Cortex.* Transactions of the Second Conference, November 16–17, 1950, New York. Elaine P. Ralli, Ed. 209 pp. $3.00. Josiah Macy, Jr. Foundation, New York. 1951.

OUR rapidly growing knowledge of the adrenal cortex is reflected in the increasing flood of reviews, monographs, conference reports, etc., concerned with the role of this vital gland in physiology and clinical medicine. One of the latest in this long procession is the report of the second conference on the adrenal cortex sponsored by the Josiah Macy, Jr. Foundation.

Since these conferences are conducted in a highly informal manner, with frequent interruptions of the speaker, and since this is a verbatim account of all that was said during the meeting, it reads a bit roughly in spots. This is likely to produce some confusion in the mind of the reader not familiar enough with the field to assess the significance of some of the questioning. Therefore, if he is looking for an orderly and integrated presentation of facts, he had better look elsewhere. In spite of these understandable and probably unavoidable faults, the book is a valuable addition to the available literature concerned with the adrenal cortex.

The participants, as always, were a distinguished group and the recognized leaders in the field. Their remarks, even when casual, command respect, and the material presented undoubtedly represents the trend of current thinking. The proceedings began with some pertinent comments by C. H. Li on the chemistry of ACTH, and ended with an equally significant discussion of the clinical uses of ACTH and adrenal cortical hormones by G. A. Thorn. In between came a consideration of the regulation of pituitary adrenocorticotrophic activity by George Sayres, a discussion of the relation of adrenal cortical hormones to the hypersensitive state by T. F. Dougherty, and a highly provocative account of the relationship between hyaluronidase and the adrenal cortical hormones by Jeanette Opsahl. All in all, this was a program selected with care and good judgment and is a credit to the chairman, C. N. H. Long.

It would be futile to attempt to summarize even the content of the papers here, but it is obvious that they point to a deeper understanding of how the adrenal cortical hormones work and what their real significance actually is in the economy of the body. Dougherty's observations on the relationship between cortical hormones and inflammation and Opsahl's studies on the inhibition of the spreading effect of hyaluronidase by the same hormone appear to offer a sound approach to the study of connective tissue diseases. This book is one which should be read by all workers in the field, whether they are biochemists, physiologists, pathologists, or clinicians, and by the nonspecialist who is curious as to the direction basic research on the adrenal cortex is currently taking.

---

*Recent Progress in Hormone Research.* Proceedings of the Laurentian Hormone Conference, Vol. VI. Gregory Pincus, Ed. 431 pp. $8.50. Academic Press, New York. 1951.

BY FAR the pick of the current crop of books on the adrenal cortex, this report of the seventh annual meeting of the Laurentian Hormone Conference should be in every endocrinologist's library. Ten of the 12 papers presented deal wholly or almost wholly with the adrenal cortex, a clear indication of current research trends in the hormone field. At first glance this might seem to impose somewhat narrow limitations on the book, but when one remembers that there is hardly a bodily process that is not influenced in some way by cortical activity, the scope of this book can be appreciated. It ranges the entire field of biology, contains a wealth of information of a particularly fundamental nature not often given the attention it deserves today, and deals not only with the specific activity of the adrenal steroids, but devotes more than a passing bow to certain philosophical problems pertinent to scientific inquiry. Perhaps the only serious criticism that can be leveled against it is that such a mass of data deserves a better index.

The book is concerned with novel matters, fresh points of view, and new approaches in so many diverse directions that it becomes impossible to do more than indicate what they are. All the papers are excellent and well worth reading. The list of contributors, although not exactly a Who's Who in endocrinology, well represents the active research groups operating in this country. On the other hand, there were enough distinguished members of the profession included to give the gathering all the prestige it needed.

It is perhaps unfair to single out from among so many a few for special mention, but this reviewer was particularly struck by Zuckerman's discussion of the problem of oogenesis (one of the two papers not immediately concerned with adrenal function), emphasizing one of the classical biological positions of the nineteenth century; Witschi's masterful discussion of the embryogenesis of the adrenal and reproductive glands, giving a rational explanation for the close structural similarity in these two groups of hormones; the account of the nature and biogenesis of the adrenal secretory products by the group from the Worcester Foundation, since it points the way to the solution of certain vexing problems concerning the physiology of

the adrenal cortex; and Engel's meditations on the parameters of metabolic problems, since they sounded a clarion call for a return to a consideration of the individual in biology. Biologists should not have to be reminded that life processes are almost infinitely variable and that, laudable as it may be to strive for uniformity in experimental material, the effort imposes a certain artificiality in the experimental situation. Such procedures unquestionably have their value and their place, but they also contain certain inherent dangers, tending as they do to reduce all metabolic processes to a statistic.

Other matters considered in the book, and equal in importance and treatment with those just mentioned, are a consideration of mammalian spermatogenesis; the synthesis of cholesterol; the chemistry of the adrenal steroids, their relation to salt and water metabolism, and their role in regulating protein metabolism; the physiological effects of cortisone and ACTH, and their use in the treatment of certain neoplastic diseases in man. Anyone who dispenses these potent compounds (the cortical steroids) should read these papers and ponder their significance. One is impressed by the fact that emerging slowly and hesitantly from the studies on the adrenal cortex is a new concept of the meaning of disease, a concept which may well turn out to be as revolutionary in its effects on clinical medicine as the discovery of bacteria. No one who reads this book can resist being caught up in the current of this new thinking.

Obviously the committee in charge of arrangements did a good job in selecting the participants, and it deserves the highest praise for its efforts—as does Gregory Pincus, who ably edited the deliberations.

DIETRICH C. SMITH

*School of Medicine*
*University of Maryland*
*Baltimore*

## MEMORIAL ANTHOLOGY

*Wesley Clair Mitchell. The Economic Scientist.* Arthur F. Burns, Ed. viii + 387 pp. $4.00. National Bureau of Economic Research, New York. 1952.

THIS volume might be described as a memorial anthology. Part one, on Life and Work, contains an introductory sketch by Arthur F. Burns, a personal sketch by Wesley Mitchell's wife, Lucy Sprague Mitchell (one of the most touching and beautiful personal tributes I have ever read), two professional sketches, and three memorial addresses. Part two contains three early appraisals of Mitchell's work, by Paul T. Homan (1928), John M. Clark (1931), and A. B. Wolfe (1939). Part three contains five recent appraisals: The Economic Theorist, by Milton Friedman; The Economic Naturalist, by Edwin B. Wilson; The Historian of Economic Thought, by T. W. Hutchison; The Social Scientist and Social Counselor, by Alvin H. Hansen; and The General Economist, by Joseph Schumpeter.

The whole volume is an impressive record of the life and contribution of one of the few social scientists ever to become president of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE [1938]. His personality shines through every article. He was kindly, and a little austere, a man who could command the almost passionate devotion of his followers, a man of great personal integrity and commitment to the cause of scientific inquiry. He was mistrustful of theory, especially of so-called orthodox economic theory. Edwin Wilson's description of him as an "economic naturalist" is a most happy one. He collected time series, classified them, and studied their relationships much as a naturalist collects butterflies. Yet he was more than a "mere" empiricist. As Friedman and Schumpeter both demonstrate in their brilliant essays, there is a hard theoretical skeleton to his work on business cycles which, like other skeletons, is not immediately visible to the naked eye but which gives shape to the massive empirical inquiry.

It seems a little improper, as well as impossible, to review a work *in piam memoriam* as this is, especially a work in memory of so great and so respected a figure. Nevertheless, in reading these essays against the larger background of the economic thought and practice of our day, one is haunted by a curious sense of inadequacy, almost of tragedy. With his immense gifts of character, intelligence, and capacity for hard work, Mitchell should have been not merely the founder of a school, but the founder of an age. As far as economics is concerned, however, this is not the age of Mitchell but the age of Keynes. The question as to why this is so is never asked, of course, in the volume under review, although Schumpeter comes close to asking it. The question has an importance, however, beyond the mere contrast of personalities. It is a question, moreover, which Mitchell himself would have been delighted to ask, not only because of his personal modesty and objectivity, but because it was the kind of question that he asked of all the periods of economic thought.

Mitchell, in his painstaking collection of data, his unwillingness to indulge in mere speculation, his careful empirical habits of work and thought, would seem to represent almost to perfection the ideal of the "economic scientist"—introducing almost for the first time the classical methods of nonexperimental science into the study of social phenomena. Keynes, on the other hand—intuitive, brilliant, often self-contradictory and a little unreliable, using data to illustrate his theories rather than building his theories out of the unremitting collection of hard facts—is an essentially "classical" economist, embodying many of the "unscientific" vices against which Mitchell revolted. It may be, of course, that the sweeping success of the Keynesian economics is due to its being less trouble to practice than the tedious fact-finding of the empirical school. That, however, is not the whole answer. There should be no conflict between empirical and theoretical work. In science the two activities are strictly complementary. If this is not the age of Mitchell, it may be because of a certain defect in his outlook and in his theoretical position; his too-passionate rejection of the tool of equilibrium in his search for dynamics; his insensitivity

to the necessities and identities of the system in his quest for empirical relationships; his mathematical and statistical armory too weak for the immense task to which he felt himself called.

In a sense Mitchell did for economics what Tycho Brahe did for astronomy—the collection and description of accurate observations about an economic universe which previously had been known only in a rough and general way. In beginning this task, and creating in the National Bureau of Economic Research an "observatory" to keep it going he performed an immense service to economics and he cannot be blamed for not being a Kepler or a Newton.

KENNETH E. BOULDING

*Department of Economics*
*University of Michigan*

## BRIEFLY REVIEWED

*The Creative Process.* Brewster Ghiselin, Ed. 259 pp. $6.50. University of California Press, Berkeley and Los Angeles. 1952.

THIS is an anthology of material drawn from 38 writers, mostly artists and literary men, who have attempted to describe the process by which original ideas come to them. The chief impression one derives from reading the many confessions of work habits and work methods here given is not only that the creative process is essentially spontaneous—one is more or less prepared for that—but that it takes among the minds of the great thinkers such a wide variety of forms. Certainly, on the basis of the data here presented, the reader would not be encouraged to look for any common "rules for discovery." We are therefore led to wonder what the editor has in mind when he states that the practical reason for assembling this material is that "insight into the processes of invention can increase the efficiency of almost any developed and active intelligence." It seems obvious that the contributors to this volume achieved their greatness, not by studying the creative process in others, but by yielding to an inner pressure of overpowering ideas which demanded expression quite independently of any accepted techniques.

Practical questions aside, the book provides a wealth of information about the inner workings of the mind in the creative act. Especially valuable is the editor's introduction, in which he summarizes, on the basis of the articles in the volume and other sources, what we know (and do not know) about invention. Unfortunately, scientific discovery receives scant attention. Apart from an article by Poincaré on mathematical thinking, and a very brief and not very illuminating communication from Einstein, there is nothing. Perhaps the most informative discussion is the one entitled "The Biological Basis of the Imagination," by R. W. Gerard, which is reprinted from THE SCIENTIFIC MONTHLY for June 1946.

A. CORNELIUS BENJAMIN

*Department of Philosophy*
*University of Missouri*

*Doctors in Blue.* George Worthington Adams. 253 pp. Illus. $4.00. Schuman, New York. 1952.

THIS medical history of the Union Army in the American Civil War is a popularized version of a doctoral dissertation prepared by Mr. Adams at Harvard University. After describing the chaotic condition of the Army medical department or, more accurately, the virtual absence of a medical corps at the start of the war, an account is given of the development of a fairly effective force.

Filth, disease, and medical confusion caused a far greater loss of manpower than did the machines of war. The primary problem in military medicine—namely, the evacuation of the wounded from the battlefield—had previously been almost completely ignored. As the war progressed, an ambulance corps replaced frightened musicians and flighty teamsters in the field-relief of the wounded. Conditions were so bad that in 1861 Surgeon General Tripler received a complaint about a hospital his office didn't even know existed.

The surgical care was, in large part, rudimentary. There was tremendous, antagonistic rivalry between the surgeons who were commissioned officers and those who were civilian volunteers, and accusations on both sides of experimentation and tampering were rife. The tragedy was that surgical practice was caught in a morass of ignorance of operating and aseptic techniques, but far-reaching advances in these fields were not to come for years after the war. And yet, by the end of the war, it was the considered opinion of many contemporary observers, among them prominent Europeans, that the medical care was a tremendous improvement over what had formerly been available to soldiers in wartime.

The absence of chronological unity in this volume is regrettable and serves to make it more a treatise than a gripping narrative. It should, nevertheless, prove to be of great value to students of medicine and of the Civil War.

RICHARD B. BERLIN

*Mount Vernon, New York*

*Introduction to Geology.* (3rd ed.) E. B. Branson and W. A. Tarr; rev. by Carl C. Branson and W. D. Keller. x + 492 pp., 434 figs. $5.50. McGraw-Hill, New York. 1952.

THAT this well-known textbook has been popular with instructors and students is shown by the fact that it has been in use for sixteen years and is now in a third revised edition. Both the original authors were experienced field geologists as well as teachers, and their firsthand knowledge is evident in the textbook. The geologists who made the revision, one a son of the senior author, and the other the head of the Department of Geology at the University of Missouri, have drawn also upon their wide field and extensive teaching experience. All of the authors were, and are, adept in presenting the principles of geology to students who take a single course in the subject for its cultural rather than its professional aspects. The book thus is useful to

laymen who wish to understand the significance of geology in our modern culture.

As befits a textbook for an introductory course which may or may not lead to a further interest in geology, this one is divided into two parts: Physical Geology (318 pp.) and Historical Geology (176 pp.). If the reviewer wished to find any fault, it would be with the too brief treatment of historical geology. He would plead for a "popular" textbook written entirely from the viewpoint of earth evolution—causes and effects woven into an intriguing fabric.

The book is excellently illustrated with diagrams and photographs that bring striking examples of field phenomena into the classroom and the home study.

It is to be hoped that this text will reach an even wider group than it has in the past, especially educated laymen who have missed the beauty, majesty, and significance of the geologic past.

ARTHUR BEVAN

*Illinois Geological Survey*
*Urbana*

*Forest Entomology.* (3rd ed.) Samuel Alexander Graham. xii + 351 pp. Illus. $6.00. McGraw-Hill, New York. 1952.

THIS textbook is far more than a third revision of *Principles of Forest Entomology,* first published in 1929 and revised in 1939. Many advances in forest insect research, including increased knowledge of the insects and their ecology, utilization of silvicultural practices in the prevention of devastating insect outbreaks, evolution of methods for predicting outbreaks, and the development of new synthetic insecticides such as DDT as a practical means of controlling defoliating pests over large and inaccessible areas, have contributed to the control of pests that ravage our forests. These and many other new findings have been skillfully woven into this revision, which practically meant writing a new book.

Recent legislative acts that have implemented forest pest control undertaken cooperatively by federal, state, and private agencies are discussed. In two new chapters the author describes methods of forest insect surveys—including detection and appraisal of damage—and also insecticides and their effects. The principles of forest entomology are stressed in chapters covering reproductive potential, environmental resistance, population levels, direct control—including chemical methods—and methods of indirect control—especially by parasites, predators, and silvicultural practices. Chapters 14 through 19 cover representative species selected from each important ecological group (leaf-feeding, sap-sucking, meristematic, phloem, phloem-wood, and wood destroyers) of forest insects to illustrate basic principles and control practices. Other species not mentioned in the text are included in the bibliography.

This textbook is very timely, for there is greater realization now than ever before that insects are a primary drain on our forest resources, and that much of the loss can either be prevented by sound forestry practices or minimized by the prompt application of control measures.

Dr. Graham is to be congratulated for producing a volume that will be of great use to teachers, students, forest entomologists, and practicing foresters.

---

*Important Tree Pests of the Northeast.* (2nd ed.) Edited by Committee on Tree Pest Leaflets, New England Section, Society of American Foresters. 191 pp. Illus. $2.00. Evans Printing Co., Concord, N. H. 1952.

IN RECENT years forest owners and public officials have become increasingly cognizant of the injury that insects and diseases cause to our forest and shade trees. The need for a concise, authoritative treatment of the more important insect pests of the Northeast led to a first edition of 50 tree pest leaflets in 1940. Their popularity is evidenced by the committee's having distributed more than 300,000 copies to individuals seeking information on the recognition and control of forest pests.

The tremendous progress made in research on insect and disease control has necessitated revision of practically all the leaflets. Forty-one authors well versed in entomology, pathology, and forestry have cooperated with the committee in bringing together an outstanding, up-to-date series of 56 leaflets with 82 good illustrations. Most of the leaflets include a discussion of the history and distribution of the pest, host trees, symptoms of damage, description of insect or disease, life history, control, and references.

Major insects covered include defoliators, sucking insects, borers, and weevils. Important diseases include those affecting the leaf and sap stream, bark and stem cankers, and wood rots. Other leaflets relate to fire and wildlife damage, and to spraying and dusting to control pests.

A list of common and scientific names of trees and other plants, an index to authors and their affiliations, an index to insects and diseases by host plants, and a general index are appended.

This 6″ × 9″ volume is bound in an attractive, flexible, green paper cover. It will find its rightful place in the pockets and libraries of many people interested in the welfare of our forest and shade trees.

C. H. HOFFMANN

*Bureau of Entomology and Plant Quarantine*
*U. S. Department of Agriculture*
*Washington, D. C.*

*Econometrics.* Gerhard Tintner. xii + 370 pp. $5.75. Wiley, New York. 1952.

ECONOMETRICS consists in the application of statistical procedures to economic models which have been formulated in mathematical terms. These procedures are of great importance in the verification of economic laws and are potentially useful for economic policy.

The text treats those methods of modern statistics that have been useful in economic research. No attempt

is made to give a complete development of relevant statistical theory, but rather theory is used to bring out the meaning of the methods that are appropriate for dealing with a particular economic model. The methods are amply illustrated by examples from various writers, including some of Dr. Tintner's own work. One of the excellent features of the book is the large number of footnote references to other sources, which treat in detail subjects that can only be mentioned in the text.

The book is in three parts. Part 1 is a nontechnical introduction, which deals with the scope and method of econometrics, simple linear regression, and some illustrations of economic research. Only simple mathematics is used, and the discussion is couched mainly in economic terms. The illustrations of research include the statistical determination of demand, supply, cost, and production functions by various workers, such as H. Schultz, V. Dean, P. H. Douglas, and G. Tintner. This part will be easy for any student of economics and should be sufficiently stimulating to incite the serious student to a careful study of the rest of the book.

Part 2 deals with multiple regression, multivariate analysis, and stochastic models with errors in the equations. Among the multivariate methods treated are the methods of principal components and canonical correlations, both of which are due to H. Hotelling. An example of the use of principal components is taken from R. Stone, in which he analyzed blocks of transactions in the American economy for the years 1922–38. Illustrations of the use of canonical correlations are taken from F. V. Waugh. The interesting problem of identification is discussed in detail.

Part 3 considers the difficult problem of time series analysis. The basic difficulty stems from the lack of statistical theory to deal adequately with observations which are not independent. The subjects discussed are trend, oscillatory and periodic movements, the interdependence of successive observations, and transformations designed to eliminate this interdependence.

Dr. Tintner's work should rouse the economic research worker to utilize the statistical methods of econometrics, and should stimulate the mathematical research worker in his assault upon the unsolved statistical problems.

W. S. Connor

*National Bureau of Standards*
*Washington, D. C.*

*Our Garden Soils.* Charles E. Kellogg. viii + 232 pp. $4.00. Macmillan, New York. 1952.

AN OUTSTANDING soil scientist, who gardens as a hobby, has prepared an elementary, easy-to-read, and informative book about soils for those who plant and care for vegetable and flower gardens, lawns, fruits, shrubs, trees, and other home ground plantings. It presents a nontechnical introduction to soils and a review of important soil properties and their significance to growing plants. There are excellent discussions of soil structure, organic matter, water and its proper use, acidity and alkalinity, and soil fertility. The importance of each of these factors and of others to growing plants is explained, and methods for their improvement or adjustment are described and discussed in considerable detail. Establishing and maintaining lawns, starting and moving plants, and garden planning are given attention. A particularly valuable chapter deals with things to consider in appraising soil and other planting site conditions. Many plant growers seemingly are not aware of the importance of some of these site factors to the success or failure of their plantings.

The book provides directions for doing many things and lists materials and amounts to use. Recommendations are adapted to various areas of the United States. The appendix contains a compilation of soil and other site requirements of over four hundred plants commonly used for garden and home ground plantings; other worth-while reference materials are included.

This little book should be a valuable addition to the libraries of vegetable and flower gardeners, horticulturists, nurserymen, landscape gardeners, and those who plant and care for gardens and home ground plantings both in the city and on the farm. It should also serve as a valuable reference for courses in horticulture and landscape gardening.

G. A. Johnsgard

*Fargo, North Dakota*

*Flowering Trees of the Caribbean.* Illustrated by Bernard and Harriet Pertchik, with an introduction by William C. White. xii + 125 pp. $10.00. Rinehart, New York. 1951.

THIS beautifully illustrated book will be welcomed by all lovers of trees, and especially by travelers in the tropics, who will use it as a guide to the identification of the gorgeous trees they will see almost everywhere; later they will find it a powerful adjuvant to the memory of the beauty they have once seen, and hope to see again. The Alcoa Steamship Company, which defrayed the cost of the art work and the engraving, is to be thanked heartily for this service, since the result will be used and and enjoyed by many people, and we have hitherto had no such book as this. The drawings are so lifelike that almost any of the plants treated here can be recognized from the illustration alone.

The selection of the trees for illustration was made in consultation with a group of eminent advisers. Naturally, the most famous and most beautiful of the tropical trees are included. The reviewer regrets that so beautiful a tree as the mango was not included, and it seems that one of the extraordinarily handsome palm inflorescences, that of the sugar palm, *Arenga saccharifera,* for example, might have been painted. *Melia azederach* might well have been replaced by *Coffea arabica,* which is beautiful as well as important in the Caribbean region.

This is a splendid volume, however. The descriptions are better than is usual in such a work, and most of

the plates are magnificent, although *Triplaris surinamensis* and *Eugenia malaccensis* are not quite true to the colors as the reviewer has seen them. The plate of *Couroupita guianensis* is the reviewer's favorite and is really exciting. The traveler will be disappointed, however, to find the flowers much smaller than the drawing suggests. The shapes and colors are present in nature just as they are shown, but the passing, and perhaps somewhat wearied eye, may not see them as clearly as the artist did. The pictures of *Jacaranda, Tabebuia, Cassia, Lagerstroemia* and *Plumierea* are especially fine. The painting of *Ochna mossambicensis* is charming, but the attribution of a sense of humor to nature does not appeal to the botanist, who may himself have a sufficiently whimsical turn of mind to perceive what the author of the caption meant.

This is a book to be opened with excitement and pleasant anticipation; to be leafed through with enjoyment again and again. One puts it down with regret that there is not more of it and a wish for many more of its kind.

CARL D. LA RUE

*Department of Botany*
*University of Michigan*

*Race-Relations in Ancient Egypt. Greek, Egyptian, Hebrew, Roman.* S. Davis. xiii + 176 pp. $4.50. Philosophical Library, New York. 1952.

BY ITS central location the land of the Pharaohs was the meeting place of different cultures and races of antiquity. For the ancient world, Egypt was as typical a melting pot as the USA is in the modern world. Yet, through several millennia the Egyptian pot was unable to melt away all the cultural, linguistic, and religious barriers and the racial marks of the people that came into contact with it either through infiltration and immigration or through force and occupation.

In the contact of the four ancient races it is easy to discover a parallel of the problems of assimilation in our world. One is also inclined to conclude that it has always been difficult to reconcile people whose ideals, culture, civilization, and religion vary. The idea of the unity of mankind conceived by Alexander the Great might have led to the creation of the Roman world-empire. Rome was successful, however, in uniting some of the semicivilized races only. It was unable to develop into a "United Nations."

It is significant that the author, a classical archaeologist, wrote his well-documented book on race relations of the classical world while he was a professor in South Africa, today one of the hottest spots of racial controversies. The first part of the work discusses with a fresh viewpoint the Greek contact with Egypt in seven chapters; the second part, in five chapters, deals with Judaization and the origin of anti-Semitism; the two chapters of the third part describe the Roman attitude toward race.

There is a great wealth of information on many interesting historical details, both in the very concisely written text and in the large number of footnotes, which carry references to first-rate authorities in Egyptology. A short bibliography finishes the well-printed book. A historical map would have been of great help.

CLAUDIUS F. MAYER

*Armed Forces Medical Library*
*Washington, D. C.*

*Flamingo Hunt.* Paul A. Zahl. 270 pp. $3.50. Illus. by Fritz Kredel. Bobbs-Merrill, New York. 1952.

A QUEST with a happy ending is vividly described by Paul Zahl, who set out to find the nesting grounds of flamingos in the Bahamas. Having first become interested in the Bahamas because of a murder, he returned on three different expeditions to follow all clues that might lead to the nesting grounds of the great, rosy birds. Under the tropical sun, through salt shallows and mangrove swamp, he followed the countless inlets of Andros and Inagua islands and describes not only the splendor of the "fillymingo herds," but gives detailed and fascinating accounts of their habits, such as their apparent ability to vanish into thin air despite the brilliant red and black of their coloring. Camping on coral rock, among prickly pear and thorn bushes, with crabs and mosquitoes as constant visitors, or sailing through the shallows in a small fishing boat, he notes with a naturalist's trained eye the marine and shore wildlife about him.

Native Bahamians helped or hindered him; with Captain Robbie Ferguson as guide he learned many of the ways of the fisherman of securing food and preserving it by sun-drying. No one who reads the book will ever forget Robbie or his sons.

Dr. Zahl uncovered some of the reasons for the decline in the great colonies of flamingos that were once reported on Andros. With the backing of the National Audubon Society, these were reported to the Bahamian government, which is now taking measures to prevent further destruction of these beautiful birds.

Fritz Kredel has furnished the delightful little black-and-white drawings for each chapter head.

LUCILE Q. MANN

*Washington, D. C.*

*The Design and Analysis of Experiments.* Oscar Kempthorne. xix + 631 pp. $8.50. Wiley, New York; Chapman & Hall, London. 1952.

PROFESSOR KEMPTHORNE has written an unusually complete and readable review of the entire field of experimental designs in his book. The text is written in part for students taking course work in the design of experiments, but primarily for students of statistics, and statisticians who must know the basic theory behind the construction and the use of experimental designs. Actual numerical examples have been held to a minimum, but the text seldom skimps in illustrating with extensive algebra the development of the analysis of variance for each design, and the

associated problems of obtaining the variances of different treatment contrasts, missing plot adjustments, efficiencies, and unbiased tests. In addition, the actual construction of the designs is explained through the use of elementary Galois fields and finite geometries.

The early chapters contain a survey of the general field of statistics, with particular emphasis on least squares and the general linear hypothesis. From here the author moves through the simplest linear models, problems of randomization, additivity, transformations, covariance, and components of variance. The two basic designs, the randomized block and the Latin square, are then explained in great detail. The discussion on the differences between the finite and infinite models makes the chapters on the Latin square of special value.

The chapters on factorial designs are excellent. Beginning with the simplest forms, the reader is taken in gradual steps through to the general $p^n$ factorial systems and mixed factorial designs. Of particular merit is the discussion on confounding, with its very neat notational methods. Lattice designs are exhaustively treated. The construction and analysis of balanced and partially balanced incomplete block designs are also discussed. The text includes a chapter on the problems of plot size and shape, another on power and the analysis of variance, with an illustration of the use of Tang's Tables (which are included in the appendix), and other chapters on long-term experiments and combining groups of experiments.

The book's frequent reference to newer statistical tools and concepts such as Tukey's test for nonadditivity, weighing and cross-over designs, designs using scores, nonparametric methods, decision theory, etc., increase its value as a text for students. In many instances these subjects are mentioned only tangentially, but the advertising value of such comments is very great.

In short, the book is comprehensive. It is certain to become an integral part of the working library of consulting statisticians and students of statistics. It should also find a ready audience among research workers. To further improve the book, the reviewer hopes Professor Kempthorne will add a vastly expanded index in future editions.

J. S. HUNTER

*Institute of Statistics*
*University of North Carolina*

*Eclipses of the Sun.* Samuel Alfred Mitchell. xv + 445 pp. Illus. $6.50. Columbia University Press, New York. 1951.

THIS book, the fifth edition of which has now been published, is a curious mixture of popular and scientific literature. It reads easily and might therefore appeal to nonscientists. It gives an extensive account of most of the more recent eclipses and discusses in detail many of the problems which can be brought nearer to a solution by observations during an eclipse.

It is greatly to be regretted that the presentation of the physical theory needed for an interpretation of the observational results is often completely inadequate and inaccurate. Chapter X, especially, contains a host of inaccuracies. To call quantum theory Planck's theory can be defended, but to ascribe to him Bohr's relation $E_1 - E_2 = h\gamma$ is a serious slip. Similarly, the section dealing with nuclear physics—which certainly started earlier than 1932!—is full of half-truths and mistakes. It is not altogether clear to me why this section is included at all, since it is nowhere applied to eclipse problems.

The final chapter gives a survey of Solar Problems, Solved and Unsolved. I beg to differ with the author on the point of light deflection. As far as I can judge, the available evidence points clearly to a definite difference between the observed light deflection and the theoretical one. It is only to be hoped that the eclipses of 1954 and 1955 will give generally accepted observational data on this important and controversial point.

D. TER HAAR

*Department of Natural Philosophy*
*St. Andrews University, Scotland*

*Handbook of Turtles: The Turtles of the United States, Canada and Baja California.* Archie Carr. 557 pp.; 37 line drawings, 23 maps, and 82 half-tones. $7.50. Comstock Publishing Associates, Ithaca, N. Y. 1952.

IN A 46-page introduction, Archie Carr has treated the general natural history of turtles, their physiology, behavior, and intelligence, their growth and age, and their economic uses. Methods of collecting turtles are also discussed.

There is a revised terminology of the epidermal shell and the bony shell which, with the accompanying drawings, facilitates the identification of any of the species. This is followed by excellent keys to the families, genera, and species. Each of the 79 kinds of turtles inhabiting the United States, Canada, and Baja California is discussed with detail: its behavior, breeding, and economic importance.

The author knows and likes his turtles, and has studied them in a very personal way, as well as having absorbed important and interesting facts from scores of other writers.

Interesting anecdotes are interspersed with the scientific descriptions; for instance, we learn that the Iroquois Indians used the shells of snapping turtles in their ceremonial dances; that in 1620 the Bermuda Assembly passed "An Act Agaynst the Killinge of Ouer Young Tortoyses"—one of the early attempts at conservation in the New World; and that the Emperor Nero is said to have had a bathtub made of tortoise shell.

The numerous drawings and photographs are unusually good; there is an extensive bibliography of 68 pages and an index.

This most valuable handbook from the Comstock Publishing Associates will be appreciated by all naturalists, and others who enjoy good literature.

W. M. MANN

*National Zoological Park*

# LETTERS

## A PHYSICIST'S WIFE LOOKS AT THE FUTURE

Entropy increasing—
Only give it time;
Unprogress never ceasing,
Reducing all to slime.

Oil and gas and atoms
Expended into dust;
All our shining metal
Slipping into rust.

Eggs you can't unscramble
No matter how you work.
Soda at the fountain
You cannot unjerk.

Potentials slowly flatten.
Every warm star cools.
Wise men lose their wisdom
Averaging with fools.

Energy and matter
May be here for aye
But who will love the rainbow
When it all turns grey?

Is there in the void
Far beyond man's ken
Some Maxwellian demon
To charge us up again?

MARY M. WATERMAN

*Washington, D. C.*

## CRUIZE OF THE ARETHUSA

CATCHING up on my SCIENTIFIC MONTHLY reading, I reached the account of the Annisquam laboratory in your February issue and was reminded of an unusual book entitled *Cruize of the Arethusa.* It is Alpheus Hyatt's log of the voyage mentioned in the article.

The book comprises 70 typewritten pages under a decorative cover, all in substantial binding of cloth with leather trim. The decoration is original water color and includes a picture of the Hyatt home at Goose Cove, readily identified with your illustration, although from a point about 90° counterclockwise from that of the photograph, thus affording a partial background of water and boat, presumably the *Arethusa* itself. A companion volume of similar outward appearance is a case of well-mounted photographs, which include the boat, its personnel, and scenes mentioned in the text.

The latter is a day-by-day account of the seamanship and tribulations of the voyage; also discussion of scenes and events at numerous points visited en route to and from Anticosti, as well as at that island. Dredging is mentioned but once; geology and photography receive much more attention. The first entry is dated "Annisquam, June 16, 1881," and the last is a brevity of August 16, as follows:

The last day of my estimated absence. Sighted Cape Ann a little on the weather bow. The *Arethusa* carries a rainbow in the foam under the lea-bow as she always does, God bless her, when in sight of that dear land.

Although my special field of science does not include all the interests of a naturalist, I enjoyed rereading the book in the light of Dr. Dexter's article.

JEANNE BURBANK

*Washington, D. C.*

## ZERO

There's no such thing as nothing:
It's just a term we choose
To designate an utter void,
That Nature does not use.

Our minds are much too shallow
To grasp how it can be
That what had no beginning
Ends in eternity.

VELMA WEST SYKES

*Kansas City, Missouri*

## OMNISCIENT PAINE

ALTHOUGH Thomas Paine's political and social philosophy is being discussed more now than ever before, few people are acquainted with his scientific thoughts. Only a few are familiar with the fact that Paine invented the iron suspension bridge, and that it was his model which was the first one to be erected. It was erected over the Ware River in England.

His idea of the use of steam in the field of transportation is another unfamiliar fact. Many think it was his suggestion that inspired Robert Fulton to apply the steam engine to water navigation. Here is Paine's observation:

As the limits of the mechanical powers, properly so-called, are fixed in nature, no addition or improvement otherwise than in the application of them can be made. To obtain a still greater quantity of power, we must have recourse to the natural powers. Of this kind are wind and water, to which has since been added steam. The first two cannot be generated at pleasure—we must take them when and where we find them. It is not so with the steam-engine; it can be erected in any place, and act at all times, where a well can be dug and fuel can be obtained.

I have just come across a statement that leads me to believe that he had a concept of atomic energy. Here is the significant paragraph, taken from his letter to Thomas Jefferson (June 25, 1801) on the subject "On

the Means of Generating Motion for Mechanical Uses." He states:

> When we consider the wisdom of nature, I must think that she endowed matter with this extraordinary property [energy] for other purposes than that of destruction. Poisons are capable of other uses than that of killing. If the power which an ounce of gunpowder contains could be detailed out as steam or water can, it would be the most commodious natural power. . . .

And in an essay on "Useful and Entertaining Hints," he makes this prophetic statement, "Perhaps a few feet of surface conceal a treasure sufficient to enrich a kingdom."

The versatility of Paine's mind has yet to be appreciated.

JOSEPH LEWIS

*Purdys, New York*

## FREEDOM TO SEEK AND SPEAK THE TRUTH

THE July issue of THE SCIENTIFIC MONTHLY, just in, contains an article by Taeusch on "The Unlisted Freedom: Science" and a letter by Philip M. Smith, both carrying the banner for a concept of freedom that has been the subject of so much febrile comment and activity. In our circles, to be a mugwump or to join forces with the opposite side would certainly be undiplomatic and tactically unfortunate; to nearly all of us such an action would also be improper.

Exposed to this doubt, I should like to risk a comment which could to some appear to be on the other side. However, I believe it to be squarely on the side of freedom and to be directed toward an understanding which will give it the place deserved and sought.

Dr. Taeusch (p. 16) asks a series of questions, as though they were absurdities: e.g., "To what extent may the teacher of the alleged social sciences speak his mind freely?" In terms of freedom for *all* of us, not just this teacher, the answer seems not to be difficult to find. This teacher may speak freely as a citizen on anything, but as a professor he has a most serious obligation to present his subject, for which society gives him faith and responsibility, with complete and absolute fairness, to the best of his ability, his opinions no more than other opinions, if as much. One of our finest lectures used to be given by a man who had a vigorous personal theory; afterwards our students more than once asked which of the theories presented was his. Partial truths, unless exceptionally well labeled as such with no intent to sell them, are not truths. When, as specialists, the world looks to us and accepts our words, we have one of the greatest of obligations to present what we believe to be the whole, undistorted truth, else we should not speak. In nearly every field, in the alleged social sciences among others, the use of propaganda and salesmanship, bias rather than the truth, has come from some emotional speakers. It is this sort of thing that leads, I think, to some of the reaction against our claims for freedom.

Another question asked by Dr. Taeusch is, "Shall a mathematician remain silent when a legislature 'simplifies' the value of $\pi$?" The answer is that, as a *mathematician,* he jolly well shall, and we shall have less trouble with our freedom. Why? Because this hypothetical legislation is no different from a legislated disposition of the sun with daylight saving, or a legislated metric system. There is no challenge in it which changes the ratio of diameter and circumference, no ruling which defies mathematical truth. The question indicates the high emotional content and the unreasoned demand for freedom which make it hard to gain a respectable freedom which we really are entitled to desire and to have, a freedom to seek and to speak the truth. License to present bias as a purported truth is exactly the thing we fight, when this bias is against us, and we must not put ourselves in the position to appear to seek the very privilege to which we are so much opposed. This paradox confuses the opponents, as well it may.

Quite possibly even President Lowell, cited by Dr. Taeusch as saying that censorship implied approval of that which remained, spoke in a disturbed moment, upset by an emotional group which confronted him. Analyzed, this statement rather suggests that censorship of evolution as subject to revision means that we must subscribe to Genesis, that we cannot censor genuine bigotry without subscribing to hypothesis as truth, or that we cannot censor a professor of English for attempting to impose his political ideas on his students with might and main because we must approve of his freedom to speak English. In short, we lose the freedom to censor what distorts the truth. To us censorship of truth itself is intolerable; this is our basic thought. It is not always seen by those who wonder why we are disturbed, to them paradoxically, over challenges that, since we appear to dislike the same sort of things they dislike, are synonymous with that one permissible (?) censorship, censoring of censors.

The burden of freedom is a national burden—or greater—not an academic one. It is one which, by and large, has wide agreement, not just agreement on the campus. Our opponents do not indicate any wish that we refrain from seeking the truth, but quite the opposite.

We shall perhaps do better if, instead of feeling that we are not understood, we seek to understand, and when, instead of ridiculing our opponents and claiming a rather large degree of goodness, we seek to repair those deviations from the truth for which we are responsible, for they occur on as well as off campuses. A better understanding and a more careful attention to the truth may well decrease the hazards of a censored existence. The majority on the side of freedom may then be such that those who wish still to stand against freedom will find free soapboxes, ample atmosphere, indulgent police, and few listeners.

MAX S. MARSHALL

*School of Medicine*
*University of California Medical Center*
*San Francisco*

# ASSOCIATION AFFAIRS

## HOTEL HEADQUARTERS, AAAS SECTIONS AND SOCIETIES, ST. LOUIS MEETING

ONE of the fundamental reasons scientists attend scientific meetings is to take advantage of the opportunity to renew contacts with former colleagues, professors, and students—and to meet, and exchange opinions with, other workers in the same fields of science. A AAAS meeting has an additional, unique advantage in that research workers in different disciplines are brought together. The basic pattern of the housing and session room arrangements, however, is the logical one of grouping specialists and closely related organizations together. Thus a large participating society is assigned an individual hotel—where the integrity of its own sessions is assured, and cooperating societies with joint sessions will share the same hotel. Societies in closely related fields of science generally have headquarters hotels that are close together, to make it easier for those who wish to attend parts of concurrent sessions. AAAS sections are similarly grouped.

At the 119th Meeting of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE in St. Louis, December 26–31, 1952, this basic plan has been followed. As indicated in the Preliminary Announcement of this Sixth St. Louis Meeting (THE SCIENTIFIC MONTHLY, 74, 376 [1952]), the center of the week's activities will be the Kiel Auditorium, within a few blocks of all the downtown hotels—the Jefferson, Statler, De Soto, Lennox, Mayfair, and Mark Twain. This modern, well-equipped convention hall will be the site of the general symposia; the sectional programs in physics, chemistry, geology and geography, botany, psychology, the social sciences and agriculture, engineering, medical sciences (including medicine, dentistry, and pharmacy), and industrial science; the sessions of the Oak Ridge Institute of Nuclear Studies and of the Conference on Scientific Manpower II; the Annual Lecture of the National Geographic Society, and the Biologists' Smoker, both on the evening of December 29. The physical relationships of the Kiel Auditorium's session rooms, the Main Registration, the Visible Directory of Registrants, the AAAS Science Theatre, and the Annual Exposition of Science and Industry are almost ideal.

The Jefferson Hotel, AAAS headquarters, will be the locale of such evening events as the Phi Beta Kappa Annual Address, December 27; the AAAS Presidential Address, December 28; the Sigma Xi Annual Address, December 29; and the Annual Address of the Scientific Research Society of America, December 30. It will also have the sessions of the Academy Conference and of certain sections and societies (see tabulation at end of article). The Statler will be headquarters for AAAS Section F, the Society of Systematic Zoology, and, in general, all biological and medical groups. The science teaching societies will occupy the Hotel De Soto.

The three mathematical societies will hold all their sessions on the campus of Washington University and will be housed in the hotels most convenient for them—i.e., the Roosevelt, Chase, Melbourne, and Sheraton. With the exception of these hotels, which are reserved for the mathematicians and which are two to four miles to the west of downtown St. Louis, all the hotels that will be used are within a few blocks of each other and within a few minutes' walking distance of the Kiel Auditorium.

The hotels of St. Louis have pledged themselves to provide ample housing at moderate rates for those attending the meeting. Housing will be capably handled by the St. Louis Convention Bureau. Hotel room assignment-confirmation slips are typed in triplicate, and one of these will be sent directly to the applicant by the hotel. Those who apply early are assured the hotel of their first choice, but it must be remembered that the supply of single rooms, at single rates, is always relatively limited—it pays to apply early for them. Double rooms for single occupancy, which carry a higher rate, are more plentiful. There is no shortage of rooms, as in the spring of 1946, when wartime conditions still prevailed. Expenses can always be reduced if rooms or suites are shared by one or more colleagues or friends.

Beginning with this issue, the advertising section of THE SCIENTIFIC MONTHLY carries full-page announcements of the hotels and their current rate schedules—together with a coupon which should be filled out and sent, ***not to a hotel,*** but to the AAAS Housing Bureau in St. Louis. Applications for hotel reservations will be filled in the order of their receipt.

Individuals of course have freedom of choice of hotels but, in stating their preference, the desired rate, and the maximum rate, it is natural that those who apply latest may not secure their first

choice. Usually a person's preference is for the hotel that has been named as headquarters for his section or society. For the convenience of those planning to attend the 119th Meeting of the Association, the headquarters for the 18 sections and subsections and the 30-odd participating societies are listed below:

### Hotel Headquarters

*Downtown Zone*

| | |
|---|---|
| *Jefferson*: (800 rooms) 415 N. 12th St. | AAAS; Press; AAAS Sections B, C, D, E, H, I, K, L, M, P, and Q; Academy Conference; American Meteorological Society, Oak Ridge Institute of Nuclear Studies; Alpha Chi Sigma; Geological Society of America, National Geographic Society; American Statistical Association, National Academy of Economics and Political Science, Pi Gamma Mu; History of Science Society, Philosophy of Science Association; Association of American Railroads; American Industrial Hygiene Association, Society for Industrial Microbiology; American Geophysical Union, Conference on Scientific Manpower, National Association of Science Writers, Scientific Research Society of America, Society of the Sigma Xi, United Chapters of Phi Beta Kappa. |
| *Statler*: (650 rooms) 822 Washington Ave. | AAAS Sections F, G, Nm, Nd, Np, and O; National Speleological Society; Herpetologists League, Society of Systematic Zoology; American Society of Naturalists, Biometric Society, Ecological Society of America; American Society of Plant Physiologists, Mycological Society of America; Alpha Epsilon Delta, American Academy of Forensic Sciences, American Association of Hospital Consultants, American College of Apothecaries, American Physiological Society, American Psychiatric Association, American Society of Hospital Pharmacists, Scientific Section of American Pharmaceutical Association. |
| *De Soto*: (300 rooms) 1014 Locust St. | AAAS Cooperative Committee; National Association of Biology Teachers; National Science Teachers Association; American Nature Study Society. |

The following additional hotels, and others, are available for sleeping rooms:

*Lennox* (350 rooms), 825 Washington Ave.

*Mark Twain* (300 rooms), 116 N. 8th St.

*Mayfair* (350 rooms), 806 St. Charles St.

*Hotels for the Mathematicians (Not Downtown)*

| | |
|---|---|
| *Chase* 212 N. Kingshighway | |
| *Roosevelt* 4903 Delmar Blvd. | AAAS Section A; American Mathematical Society, Association for Symbolic Logic, Mathematical Association of America. |
| *Melbourne* 3601 Lindell Blvd. | |
| *Sheraton* 3701 Lindell Blvd. | |

### Advance Registration and Advance Copies of the General Program-Directory

As in past years, those who plan to attend the meeting may register in advance and receive both a Convention Badge and a copy of the General Program-Directory by first-class mail, early in December. The registration fee of $2.50 includes postage. Those who cannot attend the meeting but would like to have an advance copy of the General Program, the directory content of which has been increased, may also obtain it by first-class mail early in December at cost ($1.50). A coupon covering both alternatives will be found on another page in the advertising portion of this issue of THE SCIENTIFIC MONTHLY. The appropriate square should be checked.

### Sectional Sessions for Contributed Papers

The following AAAS sections will receive papers. A brief abstract should accompany each title, and these should be sent to the section secretary or program chairman *not later than September 30*—preferably earlier.

**C**, Chemistry—Ed. F. Degering, 1860 Colonial Dr., Memphis 7, Tenn.

**E**, Geology and Geography—Leland Horberg, Department of Geology, University of Chicago, Chicago 37

**F**, Zoological Sciences—Waldo Schmitt, U. S. National Museum, Washington 25, D. C.

**G**, Botanical Sciences—Stanley A. Cain, School of Natural Resources, University of Michigan, Ann Arbor

**H**, Anthropology—Gabriel Lasker, Wayne University College of Medicine, 1512 St. Antoine St., Detroit 26

**I**, Psychology—Delos D. Wickens, Department of Psychology, Ohio State University, Columbus 10

**L**, History and Philosophy of Science—Raymond J. Seeger, 4507 Wetherill Rd., Washington 16

**Nd**, Dentistry—Russell W. Bunting, School of Dentistry, University of Michigan, Ann Arbor

**Np**, Pharmacy—George F. Archambault, U. S. Public Health Service, Washington 25, D. C.

**Q**, Education—Dean A. Worcester, University of Nebraska, Lincoln

RAYMOND L. TAYLOR
*Assistant Administrative Secretary, AAAS*